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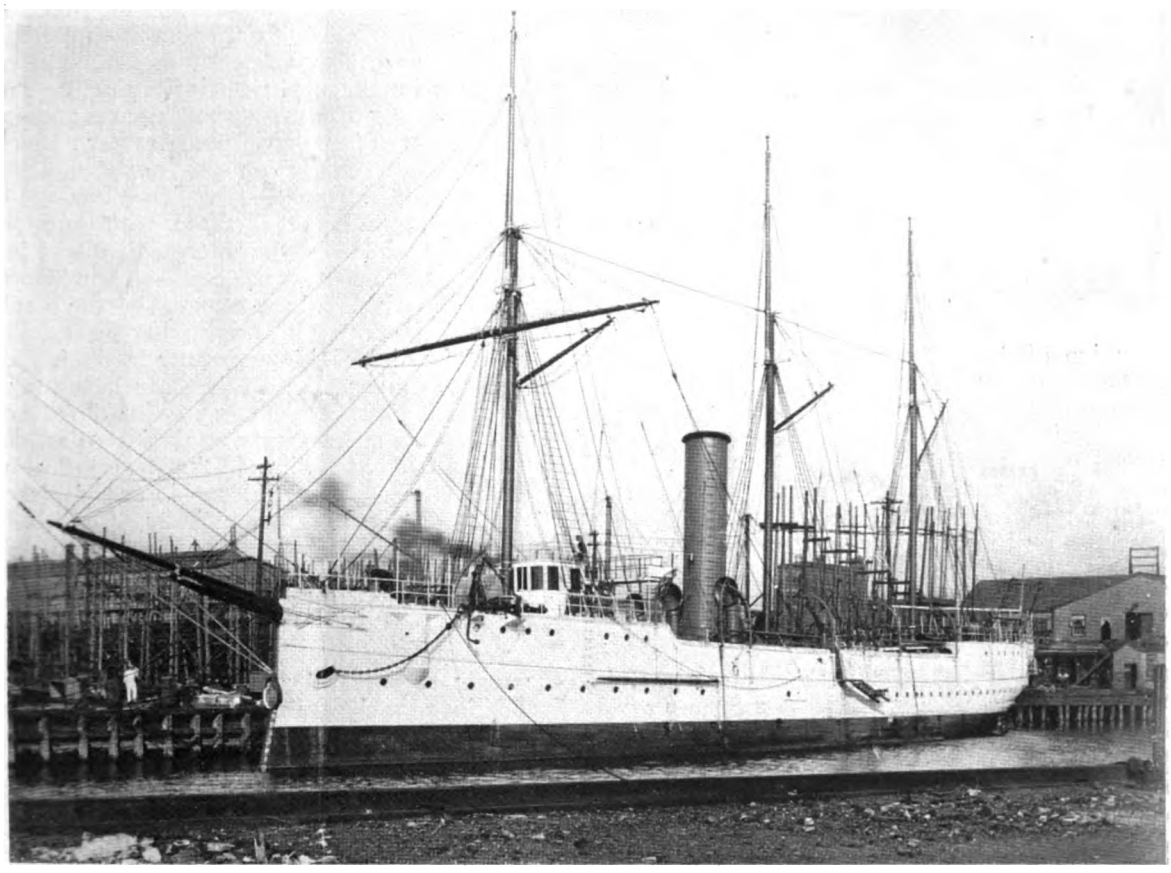
U. S. REVENUE CUTTER McCULLOCH FOR SERVICE IN BEHRING SEA.

While the Navy has been undergoing the reconstruction period, the Revenue Cutter Service has not been overlooked by Congress, for during the past five years ten new vessels have been authorized, varying in size from 250 to 1,280 tons displacement, and costing in the aggregate nearly $1,500,000. These vessels are all of the most modern type, and while built especially with reference to the duties incidental to the Revenue Cutter Service, their construction is such that they can readily be transformed into despatch boats and small gunboats, thus providing a valuable auxiliary to the regular Navy in time of war. A typical vessel of the new type is the Revenue Cutter McCulloch, now nearing completion at the yards of her builders, The Wm. Cramp & Sons Ship and Engine Building Co., of Philadelphia. This vessel is intended for service in the Behring Sea patrol fleet, and eventually to replace the Revenue Steamer Bear, for the annual voyages to Northern Alaska and Siberia. As these coasts are as yet uncharted, the navigation in the fogs and ice is consequently extremely hazardous; it was therefore determined to make this vessel of composite build, in the belief that wooden planking under water would be far safer for contact with the ice and occasional ground-



U. S. REVENUE CUTTER McCULLOCH LYING AT THE BUILDERS' YARD.

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ings on the rocky bottom. As the plans for the McCulloch were completed before the appropriations for the 1,000 ton gunboats were secured, this makes the new revenue cutter the first composite built Government vessel of modern construction.

She is 219 ft. long over all, 33 ft. 4 in. breadth of beam molded, 14 ft. mean draft, and 1,280 tons displacement. The frames, and plating above the water are of mild open hearth steel; the stem, stern frame and rudder are of manganese bronze. The entire stem is made in one piece, and is the largest single casting of manganese bronze ever made in this country, its total weight being 14,000 pounds. The physical requirements for this material were a tensile strength of not less than 50,000 pounds per square inch, an elastic limit of at least 18,000 pounds per square inch, and an elongation of not less than 18 per cent in a length of 2 in. The actual results obtained from the tests exceeded the requirements in every instance, thus demonstrating that if strength alone was considered, this bronze is superior to the best wrought iron forgings, and equal to the best forgings of steel. In addition to a flat keel plate of 20 lb. steel and the 15 lb. vertical keel plate, there is a main wooden keel of Puget Sound fir, sided 15 in. by 17 in. in depth, and a false keel of the same material, 3 in. thick and 15 in. in width. There is a steel bilge strake, with numerous diagonal plates connecting it to the outside plating above the water line. The planking extends from the wooden keel to a sheer line about 2 ft. above the water line, amidships. It is of selected Puget Sound fir, and with the exception of the garboard strake, is 5 in. thick on the frames of the vessel and reduced over tie-plates and other plating, to make fair work. The planking is secured to the frames by Tobin bronze bolts, 15-16 in. diam. in the shank. The heads of the bolts are let into the planks on the outside, and covered over with wooden plugs. The nuts on the inside are set up on thin iron washers, with hemp grommets well soaked in red and white lead, underneath. The upper edge of the top strake is protected by a beveled angle iron, riveted to the plating.

Externally the McCulloch presents a handsome appearance; she is rigged as a three-masted schooner and has a bowsprit and jibboom, thus enabling her to carry a large sail spread, to be used as an auxiliary while cruising in the Behring Sea. Her stem is fitted with a port for a 15 in. torpedo tube. Her armament will consist of four 6-pounder, rapid firing rifles, arranged in sponsons, two forward and two aft. It is expected that she will be capable of maintaining an average speed of 16 knots an hour.

Her propelling machinery consists of one vertical direct acting, triple-expansion engine, capable of developing 2,400 indicated horse power when using mild forced draft. The cylinders are 25 in., 37 1-2 in. and 56 1-4 in. dia. respectively, with a common stroke of 30 in. All three cylinders are fitted with working linings, and the intermediate and low pressure cylinders are steam jacketed. The main pistons are of cast steel, conical in shape. Each is fitted with two cast iron packing rings, 5-8 in. wide, 3-4 in. thick, cut obliquely and tongued. The piston rods are of high tensile open-hearth steel, 5 in. dia. The connecting rods are of the same material, 5 in. dia. at the upper ends, 6 1-2 in. at the lower ends, and 75 in. long between centers. The requirements for the steel used for piston rod, connecting rod and valve stem forgings were a tensile strength of 80,000 pounds per sq. in. and an elongation of not less than 25 per cent in a length of 2 in. Test pieces 1-2 in. square cut from these forgings, were bent double, flat on themselves, after being quenched from a cherry red heat, without showing the slightest sign of fracture. The crank, line, and propeller shafts are forged of mild open-hearth steel. The crank shafts are solid forgings in two sections; the crank pins are 10 1-2 in. dia. and 13 1-2 in. long. The thrust and intermediate shafts are 9 3-4 in. dia. and the propeller shaft 10 1-2 in. dia. The front columns supporting the engine are of forged steel 6 in. dia. The requirements for the steel used in forging the columns, reversing the main shafting were a tensile strength of 60,000 pounds per square inch, and an elongation of not less than 25 per cent in a length of 8 in. The high pressure cylinder is fitted with one piston valve, 14 in. dia.; the intermediate and low pressure cylinders are each fitted with a double ported slide valve. All are actuated by the Stephenson link motion, with double bar links. The travel of the high and low pressure valves is 7 1-2 in., and the intermediate valve travels 6 1-4 in. All eccentric straps are of composition, lined with white metal. The reversing engine is 10 in. dia. by 18 in. stroke, and, in addition to the floating lever attachment, a special cushioning device is fitted to both ends of the cylinder. The thrust bearing is of the horse shoe type, fitted with eight collars, lined with white metal. These are mounted on two steel rods, 2 1-4 in dia. and are each held in place by composition adjusting nuts. The pedestal for the thrust bearing is bolted to the main engine bed plate and in addition the foundations for the main engine and thrust bearing are tied together by a steel plate 3-4 in. thick.

The condenser is rectangular in shape and forms a part of the framing of the engine. There are 1,253 seamless drawn copper tubes, tinned inside and outside, each 5-8 in. dia. 18 B. W. G. thick, and 4 ft. 5 in. long, between tube sheets. The total cooling surface is about 3,000 sq. ft. The inlet and outlet nozzles for the circulating water are each 10 in. dia. The tube sheets are of rolled composition, 7-8 in. thick.

The air pump is of the Blake independent, vertical, duplex type, bolting directly to the main condenser. The steam cylinders are 9 in. dia., the air cylinders 20 in. dia., with a common stroke of 12 in. The air cylinders are lined with com-

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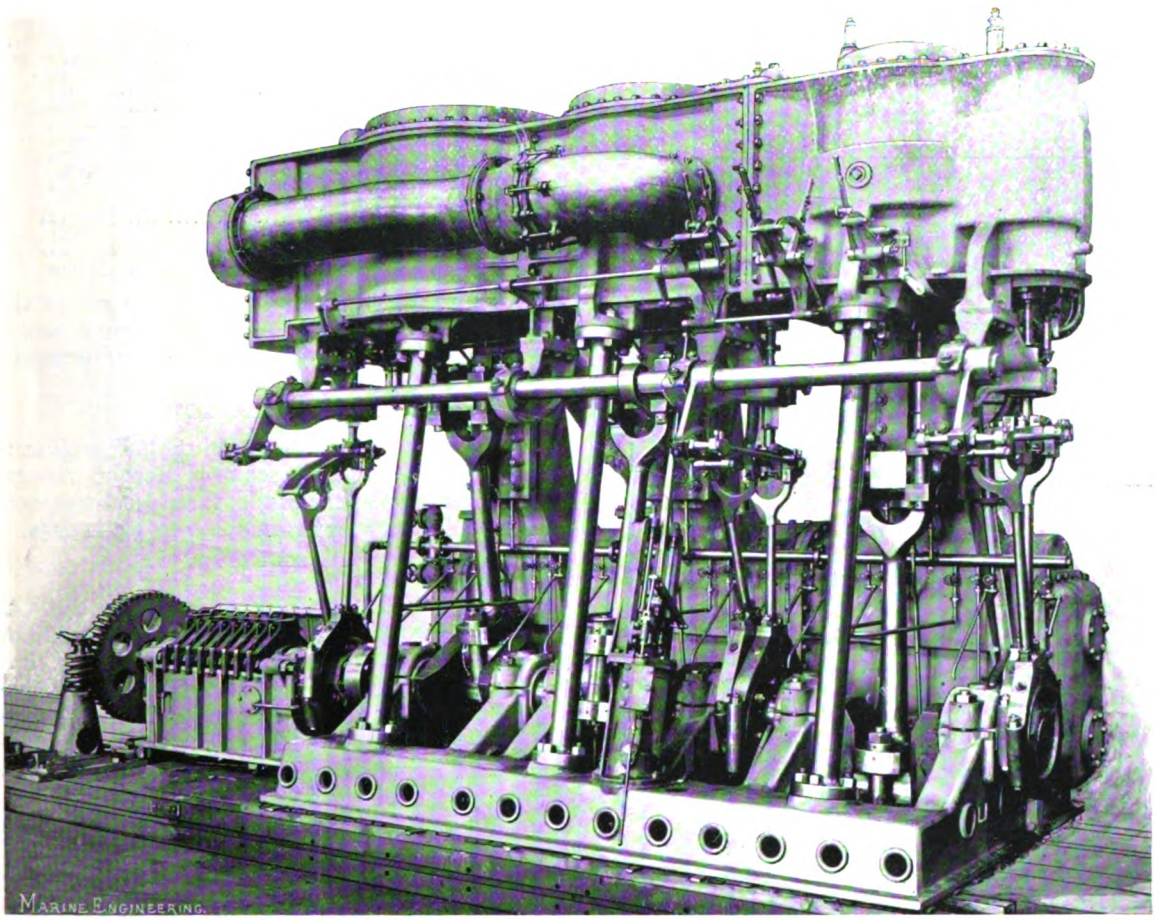
position; the valves are of the best quality of medium hard rubber, held in place by composition valve bolts and springs of phosphor bronze. The main and auxiliary feed pumps are of the Blake vertical, duplex, Naval type, with 8 in. steam cylinders, 5 in. water cylinders, and 12 in. stroke. The circulating pump is of the independent centrifugal type, operated by a single vertical engine, with a steam cylinder 8 in. dia. by 8 in. stroke. In addition to the above, there is a large fire pump, a combined fresh and salt water pump, a hand pump and an air pressure pump for forcing air into the fresh water supply tanks. Two No. 10 Korting boiler injectors are also fitted for feeding the boilers.

The propeller is of the built up type, having four blades of manganese bronze, which are secured to the cast steel hub by bronze studs. The diameter is 12 ft., the pitch (true) is 12 1-2 ft., and the helicoidal area about 43 sq. ft. The blades are 4 1-4 in. thick at the root, and taper to 3-4 in. thick at the tips.

Steam is supplied at a maximum pressure of 160 lbs. by four single ended boilers of the Scotch type, 11 ft. 6 in. outside dia. by 10 ft. long, containing a total heating surface of 5,030.7 sq. ft., and a grate surface of 168 sq. ft. Each boiler has two corrugated steel furnaces, 3 ft. 6 in. internal dia. There are in each boiler 172 ordinary tubes No. 10, B. W. G. thick, and 46 stay tubes No. 6, B. W. G., all 2 1-2 in. external diameter, and made of the best charcoal iron. The shells are each made of two plates, 19 1-2 ft. long, 9 1-2 ft. wide, and 1 1-6 in. thick. The ingots from which each shell plate was rolled, weighed, on the average, 10,000 lbs. The grates are 6 ft. in length, and the bridge walls extend from the rear end of the grate bars to the back of the combustion chambers. There is one double smoke stack, having a sectional area of 30.6 sq. ft.

There is a complete distilling apparatus, capable of supplying 3,500 gallons of potable water every 24 hours. A machine shop containing a lathe, shaper and drill press is located in the lower engine room. A steam windlass, steam steering engine, hydropneumatic ash ejector, and other modern appliances are also provided.

The machinery was designed under the supervision of Engineer-in-Chief John W. Collins of the Revenue Cutter Service.



TRIPLE-EXPANSION ENGINE OF U. S. REVENUE CUTTER MCCULLOCH.

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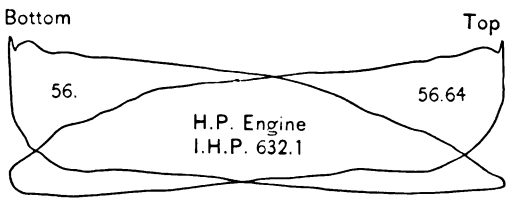
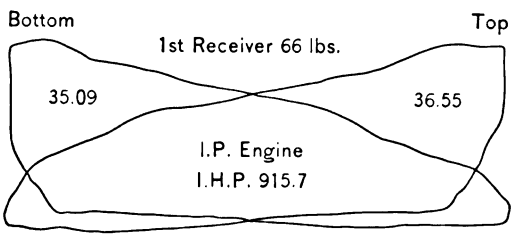
TRIAL TRIPS AND DATA.

The official trial of the McCulloch took place on April 29th, at sea, off Cape Henlopen, over what is known as the Cramp course, a distance of twelve nautical miles between two buoys. The Board appointed by the Secretary of the Treasury to conduct the trial of the steam machinery, consisted of Captain J. W. Collins, the Engineer-in-Chief of the Service, Chief Engineer F. B. Randall, and First Assistant Engineers C. A. McAllister and W. E. Maccoun. Four runs were made over the course without altering the speed or slowing the engines at the turns. The average air pressure maintained in the fire room was 1.5 in., the boilers steaming freely without great exertion on the part of the firemen. The machinery operated very satisfactorily in every particular, the bearings, with the exception of a light stream on the thrust, worked cool without recourse to the water service. Indicator diagrams were taken every fifteen minutes during the forced draft trial and at intervals of a half hour during the run under natural draft. The following data represent the average performance for the forced draft trial, during a period of four hours.

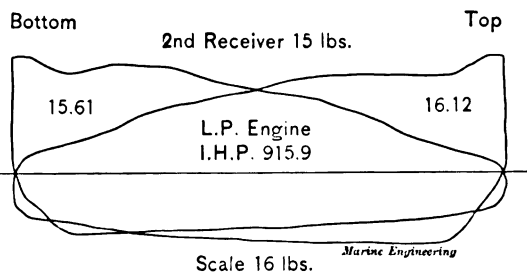
U. S. S. "McCULLOCH"



Scale 80 lbs.



Scale 40 lbs.



Scale 16 lbs.

April 29th 1897----------3.45 P.M.
Steam pressure at Engine----149 Lbs.
Revolutions per minute------154
Vacuum----------24.5 Ins.

Speed in knots per hour		17.23
Speed, maximum of the four runs		17.34
Revolutions of main engine per minute		151.8
Slip of propeller, per cent		13.14
Piston speed, in feet per minute		759
Steam pressure at boilers (per gauge)		161.3
Steam pressure at 1st receiver (absolute)		76.3
Steam pressure at 2d receiver (absolute)		28.6
Vacuum in condenser (in. of mercury)		24.5
Opening of throttle		wide
Cut-off, mean	H. P	.703
	M. P	.714
	L. P	.719
Double strokes of air pump per minute		41
Revolutions of circulating pump		165
Double strokes of main feed pump, per minute		16
Revolutions of blowers, average		756
Temperature of feed water, deg. F		125
Temperature of sea water, deg. F		51
Temperature of discharge water, deg. F		155
Mean pressures in cylinder	H. P	56.23 lbs.
	M. P	35.82 lbs.
	L. P	15.86 lbs.
I. H. P. main engine	H. P	639.5
	M. P	784.3
	L. P	815.5
Total I. H. P. for main engine		2,239.3
Total I. H. P. for main engine and auxiliaries		2,349.9
Maximum I. H. P. main engine and auxiliaries		2,598.3
Mean normal thrust, lbs		28,202
Normal thrust in lbs. per sq. in. of thrust bearing		48.1
Cu. ft. swept per minute by L. P. piston per I. H. P		5.84
Sq. ft. of cooling surface per I. H. P.		1.28
Sq. ft. of heating surface per I. H. P.		2.14
I. H. P. per sq. ft. of grate surface		13.93

The live steam connections were opened to the I. P. and L. P. cylinders during the runs, which will account for the uneven distribution of power in the three cylinders.

Japan is now doing shipbuilding and engineering work on a large scale. Recent reports showed, among other vessels, three steel steamers on the stocks varying from 1,492 to 5,790 tons.

An addition to the fleet engaged in the Canadian-Australian Mail Service has been made by the putting into service of the S.S. Aorangi, formerly running between New Zealand and London. This ship, which is Clyde built and is thirteen years old, has been re-engined and thoroughly overhauled. She is 407 ft. long, 46 ft. beam, 23 ft. 7 in. deep, and has a registered tonnage of 4,268 tons. She has accommodation for 150 passengers. The old engines were compound of 3,000 horse power, and these have been replaced by triple expansion engines of 5,000 horse power, which give a service speed of about 15.5 knots. Four new boilers have been put in to replace six taken out, the new boilers working under Howden's system of forced draught. The new engines have cylinders 32 in., 51 in., and 86 in. by 54 in. stroke. Joy's assistant cylinders are fitted to the intermediate and low pressure slide valves to balance the weight of the heavy valves and gear. Among the engine room auxiliaries is an evaporator with a capacity of 40 tons daily, large provision having to be made for fresh feed, owing to the distances between the ports of call on the Pacific route.

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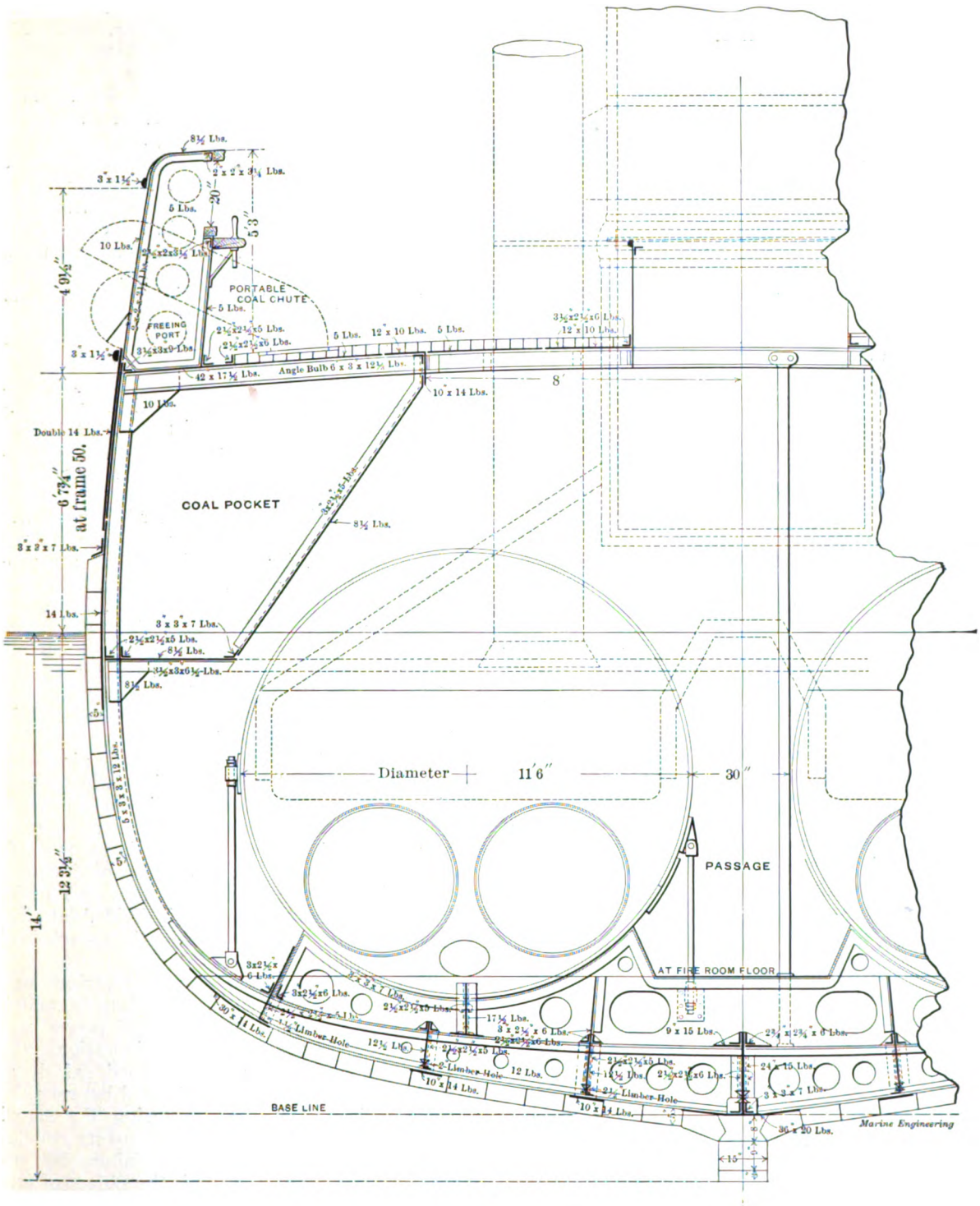

Scale ¼ in. = 1 ft.

CROSS SECTION U. S. REVENUE CUTTER MCCULLOCH, AT FRAME 50, SHOWING METHOD OF CONSTRUCTION OF COMPOSITE VESSEL.

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APPLICATION OF THE COMPOUND STEAM TURBINE TO MARINE PROPULSION.*

BY HON. CHARLES PARSONS.

It has been suggested by Sir W. H. White that a paper giving some account of the application of the compound steam turbine to the purposes of marine propulsion might be of interest to the members of this institution. The date of this paper is perhaps somewhat premature, as the Turbinia, the first boat fitted with turbine engines, has not yet completed her experimental trials, but as the results so far ascertained are in some respects remarkable, this perhaps may afford some excuse for their publication. The manufacture of the compound steam turbine was first commenced in the year 1885 with the construction of small engines for the driving of dynamos; successive improvements were made, and larger engines constructed, but up to the year 1892 the consumption of steam was not such as to justify the application of this class of engine to the purpose of marine propulsion, though on account of its light weight, small size, and high speed of revolution it presented greater advantages over ordinary engines for certain classes of work.

In the year 1892, however, a highly developed compound turbine, adapted for condensing, was constructed for the Cambridge Electric Supply Company, and when tested by Professor Ewing, F. R. S., showed a consumption of steam equivalent to 15.1 lb. per indicated horse power per hour, the boiler pressure being 100 lb., and the steam superheated to 127 deg. F. above the point of saturation. More recently, compound turbine engines have been constructed up to 900 horse power, both condensing and non-condensing, and consumption of steam as low as 14 lb. per indicated horse power with saturated steam, and 100 lb. boiler pressure, have been ascertained in engines of 200 horse power, and still lower consumptions in engines of larger size. Many of the original engines are still doing good work; some especially the larger sizes of 500 horse and upwards, are frequently kept at work for several weeks without stopping. The returns of the Newcastle and District Electric Lighting Company show a yearly cost of up-keep of 2½ per cent per annum, and the total horse power of turbines now at work in England exceeds 30,000 horse power.

In January, 1894, a syndicate was formed to test thoroughly the application of the compound steam turbine to marine propulsion, and a boat was designed for this purpose. In view of the large amount of alteration that would probably be required before a satisfactory issue was reached, and the large amount of time and expense necessarily involved, it was decided to keep the dimensions as small as possible, but not so small as to preclude the possibility of reaching an unprecedented rate of speed, should all the parts work as satisfactorily as was anticipated. The fulfilment of these anticipations was, however, much delayed, and almost frustrated, by a difficulty which, though foreseen, proved to be of a much more serious character than was anticipated. This difficulty was that termed by Mr. R. E. Froude "the cavitation of the water," or, in other words, the hollowing out of vacuous spaces by the blade of the screw, and this pitfall for the designers of screws for very fast vessels, though indicated by theory to exist, came upon us in the case of our very fast running screw, taxed beyond the usual extent, in its most aggravated form. When the boat and machinery were designed the trials of the Daring, which first drew attention to this difficulty, had not taken place.

The Turbinia—as the boat is named—is 100 ft. in length, 9 ft. beam, and 44½ tons displacement. The original turbine engine fitted in her was designed to develop upwards of 1,500 actual horse power at a speed of 2,500 revolutions per minute. The boiler is of the water tube type for 225 lb. per square inch working pressure, with large steam space and large return water legs, and with a total heating surface of 1,100 sq. ft., and a grate surface of 42 sq. ft.; two firing doors are provided, one at each end. The stokeholds are closed, and the draught furnished by a fan coupled directly to the engine shaft. The condenser is of large size, having 4,200 sq. ft. of cooling surface; the circulating water is fed by scoops, which are hinged and reversible, so that a complete reversal of the flow of water can be obtained should the tubes become choked. The auxiliary machinery consists of main air pump and spare air pump, auxiliary circulating pump, main and spare feed pumps, main and spare oil pumps, also the usual bilge ejectors; the fresh water tank and hotwell contain about 250 gallons. The hull is built of steel plate, of thickness varying from 3-16 in. in the bottom to 1-16 in. in the sides near the stern, and is divided into five spaces by water-tight bulkheads. The deck is of steel plate.

Trials were made with screws of various patterns, but the results were unsatisfactory, and it was apparent that a great loss of power was taking place in the screw. To investigate the question thoroughly, a spring torsional dynamometer was constructed, and fitted between the engine and screw shaft, measuring the actual torque transmitted. The measurements conclusively proved that the cause of failure lay entirely in the screws, and, with the object of further investigating the character of this waste of power, a series of experiments were made with model two-bladed screws of 2 in. diameter, revolved in a bath of water heated to within a few degrees of the boiling point, and, in order that the model screw should produce analogous results to the real screw, it was arranged that the temperature of the water and the head of water

* Read before the Institution of Naval Architects in London, April 8, 1897

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above the propeller, as well as the speed of revolution, should be such as to closely resemble the actual conditions and forces at work in the real screw, the object in heating the water being to obtain an increased vapor pressure from the water, so as to permit a representation of the conditions with a more moderate and convenient speed of revolution than would otherwise have been necessary.

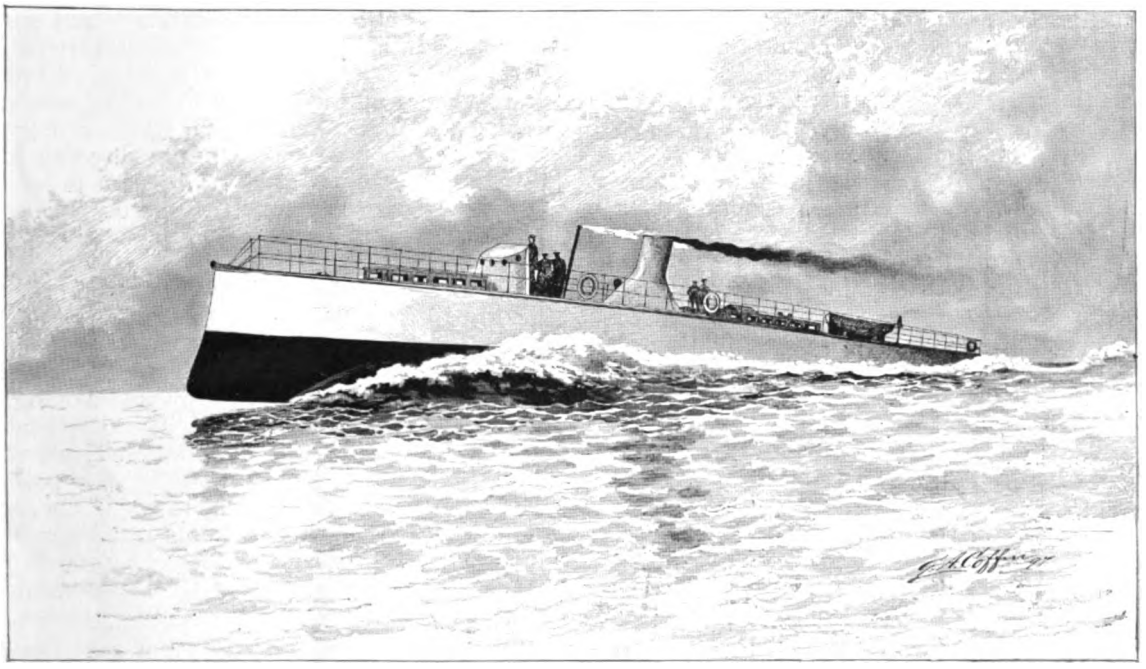
The approximate weights are:

Main Engines	3 tons 13 cwt.
Total weight of machinery and boiler, screws and shafting, tanks, etc.	22 tons.
Weight of hull complete	15 tons.
Coal and Water	7½ tons.
Total displacement	44½ tons.

The screw was illuminated by light from an arc lamp reflected from a revolving mirror attached to the screw shaft, which fell on it at one point only of the revolution, and by this means the also appeared that when the cavity had grown to be a little larger than the width of the blade, the leading edge acted like a wedge, the forward side of the edge giving negative thrust.

From these experiments it would appear that in all screws, of whatever slip ratio, there will be a limiting speed of blade, depending upon the slip ratio and the curvature of the back—in other words, on the slip ratio and thickness of blade; beyond this speed a great loss of power will occur; and that, should the speed of ships be still further increased, the adoption of somewhat larger pitch ratios than those at present usual will be found desirable.

It is not proposed here to trace further the losses of power by cavitation, but, generally speaking, the effect is felt in the case of the real ship, not in the racing of the screw, but in loss of propulsion effect. In the model experiments,



TURBINIA DOING 32.75 KNOTS ON THE MEASURED MILE.

shape, form and growth of the cavities could be clearly seen and traced as if stationary. It appeared that a cavity or blister first formed a little behind the leading edge, and near the tip of the blade; then as the speed of revolution was increased, it enlarged in all directions until, at a speed corresponding to that in the Turbinia's propeller, it had grown so as to cover a sector of the screw disc of 90 deg. When the speed was still further increased, the screw, as a whole, revolved in a cylindrical cavity, from one end of which the blades scraped off layers of solid water, delivering them on to the other. In this extreme case nearly the whole energy of the screw was expended in maintaining this vacuous space. It however, in hot water, the effect was both loss and propulsion effect and also racing, as would naturally be expected from the fact of greater vapor density of the water in the latter case rendering the cavities more stable. A series of model experiments on cavitation in cold water on the lines described would be extremely interesting, and probably instructive, but would require more elaborate, powerful and extremely high-speed apparatus than was at our disposal. It would also seem that the limitation imposed on slip ratio tends in favor of larger pitch ratio for very fast vessels.

The single compound turbine engine was now removed from the boat and replaced by three

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separate compound turbines, directly coupled to three screw shafts, working in series on the steam, the turbines being the high-pressure, intermediate and low-pressure, and designed for a complete expansion of the steam of 100-fold, each turbine exerting approximately one-third of the whole power developed, the three new screw shafts being of reduced scantling. By this change the power delivered to each screw shaft was reduced to one-third, while the division of the engine into three was favorable to the compactness and efficient working of the turbines. The total weight of engines and the speed of revolution remained the same as before. The effect on the screws was to reduce their scantling, and to bring their conditions of working closer to those of ordinary practice. The thrust of the propellers is balanced by steam pressure in the motors. The rest of the machinery remains the same, though some changes in arrangement were necessary. The usual lignum-vitæ bearings are used for the screw shafts. The engine cylinders lie closely to the bottom of the boat, and are bolted directly to small seatings on the frames of sufficient strength to take the thrust of the propellers. The center of gravity of the machinery is consequently much lower than with ordinary engines.

At all speeds the boat travels with an almost complete absence of vibration, and the steady flow of steam to the motors may have some influence on priming; at any rate, no sign of this has yet occurred with ordinary Newcastle town water. No distilling apparatus has been fitted. The boat has been run at nearly full speed in rough water, and no evidence of gyroscopic action has been observable, though such a result would be anticipated from the known small amount of these forces under actual conditions; indeed, the Turbinia has so far proved herself an excellent sea boat. The oiling of the main engines is carried on automatically under a pressure of 10 lb. per sq. in. by a small pump worked off the air-pump engine; a small independent duplex oil pump is also fitted as standby. The main engines require practically no attendance beyond the regulation of a small amount of live steam to pack the glands and keep the vacuum good.

The advantages claimed for the compound steam turbine over ordinary engines may be summarized as follows:—(1) Increased speed, (2) increased economy of steam, (3) increased carrying power of vessel, (4) increased facilities for navigating shallow waters, (5) increased stability of vessel, (6) increased safety to machinery for war purposes, (7) reduced weight of machinery, (8) reduced space occupied by machinery, (9) reduced initial cost, (10) reduced cost of attendance on machinery, (11) diminished cost up-keep of machinery, (12) largely reduced vibration, (13) reduced size and weight of screw propellers and shafting.

APPENDIX.

Trials of the Turbinia.—In December of last year several runs were made on the measured mile, and the maximum mean speed obtained after due allowance for tide was 29.6 knots per hour, the mean revolutions of the engines being 2,550 per minute. Since then new propellers of increased pitch ratio have been fitted. Further trials were made on April 1. The mean of the two consecutive runs gave a speed of 31.01 knots per hour, the mean revolutions of the engines being 2,100 per minute, the fastest run being at the rate of 32.61 knots per hour. The utmost horse power required to drive the boat at the speed of 31.01 knots is 946, as calculated from experiments on her model, made at Heaton Works, on the method of the late Mr. William Froude.

Assuming the ratio of thrust horse power to indicated horse power to be 60 per cent (which appears to be the ascertained ratio for torpedo boats and ships of fine lines), the equivalent indicated horse power for 31.01 knots is 1,576. The feed water supplied to the boiler was measured by a Siemens water meter previously calibrated under the working conditions, and found to be substantially correct. These measurements were made when running at a speed of 28 knots, and the consumption at 31.01 knots has been calculated from these measurements according to the known law between steam pressure and consumption, and by the observed steam pressures on the engines at the respective speeds. The consumption at 31.01 knots is approximately 25,000 lb. per hour, or 15.86 lb. per indicated horse power. It should be observed that the assumption of the thrust horse power being 60 per cent of the indicated horse power presupposes that the propellers are of the best form attainable, and should those now fitted be superseded by others of higher efficiency, as is possible, and indeed probable, then the figures of consumption per indicated horse power will be correspondingly improved, and the speed of the boat increased. The consumption of steam at 11.4 knots speed has been measured by meter, and found to be 2,700 lb. per hour, or equivalent to a coal consumption of about 24.6 lb. per knot.

Conditions of running of Turbinia at 31.01 knots speed

Mean revolutions of engines	2,100	
Steam pressure in boiler	200	lb
Steam pressure in engines	130	lb
Vacuum at exhaust of engines	13.5	lb
Speed of boat	31.01	knots
Calculated thrust horse-power	946	
Calculated indicated horse-power	1,576	
Consumption of steam, reduced to basis of 31.01 knots	25,000	lb
Consumption of steam per indicated horse-power per hour	15.86	lb
Total weight of machinery, including boiler, condensers, engines, auxiliaries, shafting, propeller, tanks, water in boiler, and hotwell, in working order	22	tons
Indicated horse-power per ton of total machinery	72.1	

Owing to adverse weather, these trials have been much delayed, and had finally to be made under unfavorable circumstances. They are, however, believed to be substantially accurate.

On Saturday, April 10, the Turbinia attained the highest velocity ever reached by a steam vessel, making an average of 32.75 knots on the measured mile.

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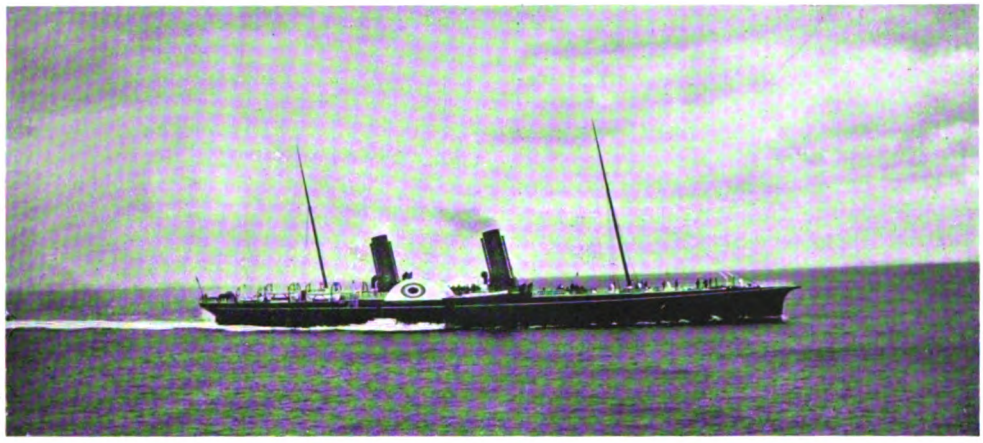
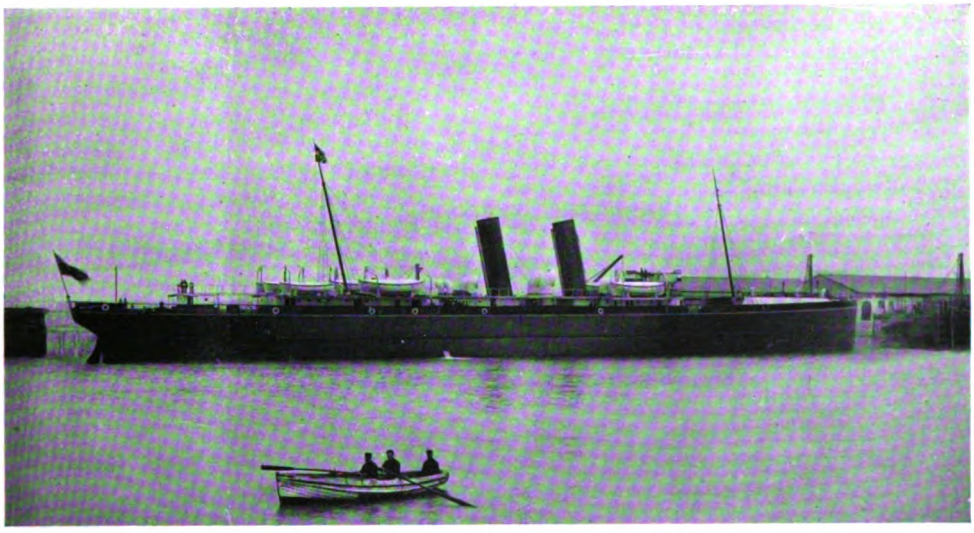
TWIN-SCREWS SUPERSEDE PADDLES.

Here are shown two types of mail steamships belonging to the City of Dublin Steam Packet Co., which claims the honor of being the oldest existing steamship company, having been founded in 1823. The paddle steamer represents the type of vessel which has maintained an uninterrupted service between Holyhead and Kingstown, across the Irish Channel, for nearly 40 years, carrying the mails. It is over this route that the American mails sent via Queenstown are ferried across the 60 odd miles between England, or more properly Wales, and Ireland. The paddle fleet consisted of the Ulster, Munster, Leinster, Connaught, and the newer Ireland. The first four named vessels have very recently been superseded by twin-screw steamers of the same names, one of which is shown lying beside her wharf, in the illustration. The wonderful record made by the old vessels for punctuality, speed and safety has become a matter of common knowledge wherever steamships are known. Now that they have been sold out of service renewed attention is directed to the service, for the record already made by the new vessels is hardly less interesting. The first of these, the Ulster, on her maiden voyage, attained a mean speed of 23.4 knots, making the across-channel passage in 2 h. 26 min.

The four original vessels of the fleet were built in 1860, the Leinster by Samuda, of London, and the Ulster, Munster, and Connaught by Laird Bros., of Birkenhead, who are very generally known on this side of the Atlantic as the builders of the Alabama. The vessels were of similar dimensions, ranging in length from 327 to 343 ft., in beam from 35 ft. to 35 ft. 2 in., and in tonnage from 1,695 to 1,750 tons. They drew 12 ft. 6 in. forward, and 13 ft. 2 in. aft. All were of iron, and the quality of material and workmanship was so good that when sold the hulls were as sound as the day they were launched. Each vessel was fitted with low-pressure oscillating,



PADDLE MAIL STEAMSHIP IRELAND WITH PASSAGE RECORD OF 20.70 KNOTS.



TWIN-SCREW MAIL STEAMSHIP ULSTER WITH PASSAGE RECORD OF 23.4 KNOTS.

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jet-condensing engines of 4,500 horse power. Working at a pressure of 26 lbs. to the square in., the paddles doing 25½ revolutions per minute. The highest speed which they attained was 18 knots, considered a wonderful performance when built. It is worth noting that the last passage made by each of these boats in 1897, was quicker than the first in 1860. During all these years none of these boats missed a passage through failure to put out, though the weather in the channel is often fearfully bad. Nor was a single life ever lost from any of the boats though the track which they cross is perhaps the most frequented by shipping of any in the world, and fogs are frequent. The vessels were fitted with new boilers and forced draught some years ago, but the engines were never changed. A record of the performances of the Connaught shows that when new the time of 1,000 consecutive passages, from pier head to pier head, a distance of 56.75 nautical miles, not making any deductions for delay by fog, storms or other cause, was 3h. 51½m. And 1,000 consecutive passages, under similar circumstances, commencing in 1885, when the ship had been overhauled and new boilers fitted, averaged 3h. 33m.

The Ireland, which is shown approaching Kingstown at full speed, was built in 1885 by Laird Bros. also. She is a steel vessel 380 ft. long, 38 ft. beam, with engines of the same type as the older boats, working at a pressure of 32 lbs. per sq. in., and indicating 7,000 horse power. Her quickest passage was done in 2h. 45m.

The four new twin-screw steamers recently built by Laird Bros. are sister ships; 380 ft. long, 41 ft. 6 in. beam, with a draught of 13 ft. forward and 15 ft. aft. They are fitted with triple expansion engines, indicating 9,000 horse power when running at 162 revolutions, with 160 lbs. boiler pressure. The record passages for these boats up to the present are: Ulster, 2h. 26m.; Leinster, 2h. 23m.; and Munster, 2h. 25m. During this passage the Leinster was sent at the rate of 24 knots for the greater part of the trip, the engine speed being run up to 172 revolutions. The Munster made her fastest passage in the face of a stiff head wind.

It will be noticed from the illustration that the new vessels closely resemble Transatlantic liners in outward appearance. The hurricane deck forward, the long stretch of deck houses amidships, and the boat deck are characteristic. These boats do not carry any freight other than passengers' baggage, being used exclusively for fast passenger and mail service. They have accommodation aboard for about 1,000 passengers. In a later issue we hope to present some views of the interior arrangements which are very handsome and convenient.

For the photographs which are here reproduced we are indebted to the courtesy of George M. Roche, Cambridge House, Montpelier Hill, Dublin.

LARGEST PADDLE STEAMSHIP AFLOAT, BRITISH OR AMERICAN?

The new paddle steamship Empress Queen, now under construction by the Fairfield Shipbuilding and Engineering Co., at Govan, on the Clyde, for service in the Irish Sea, has been described at length in British technical papers of late, with the comment that when completed she will be "the largest and most powerful paddle steamer afloat." Judging from the build and performances of other boats on the Liverpool-Isle of Man route, the Empress Queen is undoubtedly a magnificent vessel. But the British enthusiasts have evidently forgotten the existence of the Priscilla, of the Fall River Line, running out of New York. She also has some claims to the championship, if the word is permissible, and, to enable the reader to judge for himself, the descriptions of these vessels are here given, with appropriate illustrations. Every statement regarding the Empress Queen is as "big" as her admirers make, for the description is understood to be "official."

BRITISH STEAMSHIP EMPRESS QUEEN.

The Empress Queen is a vessel of 2,000 tons gross, constructed of steel throughout, and, when completed, will rank as the largest and most powerful paddle steamer afloat. She is to have engines of 10,000 I. H. P., and has been splendidly fitted up for the accommodation of a large number of passengers. The new steamer is intended for the Liverpool and Douglas service of the Isle of Man Steam Packet Co. The name Empress Queen has been given her by Her Majesty's special permission and in honor of her diamond jubilee. The principal dimensions of the new steamer are: Length, 375 ft.; breadth, 83 ft. 6 in.; depth, molded, 25 ft. 6 in. The hull is divided into watertight compartments by steel transverse bulkheads, which, besides reducing the risk of foundering to a minimum, materially augment the strength of the structure, forming valuable supports and ties between the decks and framing. The decks are four in number, and are termed "lower," "main," "spar," and "promenade." Dining accommodation for 124 first-class passengers is provided in a handsomely furnished saloon on the lower deck. The forward part of the ship is allotted to second-class passengers. The dining saloon, forward of machinery space, on the lower deck, having bar and pantry adjoining, provides ample accomodation for the second class. On the same deck, and forward of this, is a ladies' second-class saloon. The main deck above is arranged as a second-class shelter, and contains a bar, buffet, mail, and parcel room. On the spar deck aft, in houses, are several private cabins, fitted with berths, etc., in the very newest style; and amidships on the same deck is a cloak-room and combined bar and smoking-room; while all fore and aft every available space is utilized for sitting-room, there being sparred seats sufficient to seat over 560 persons. Above the spar deck is a spacious promenade deck, extending from the fore

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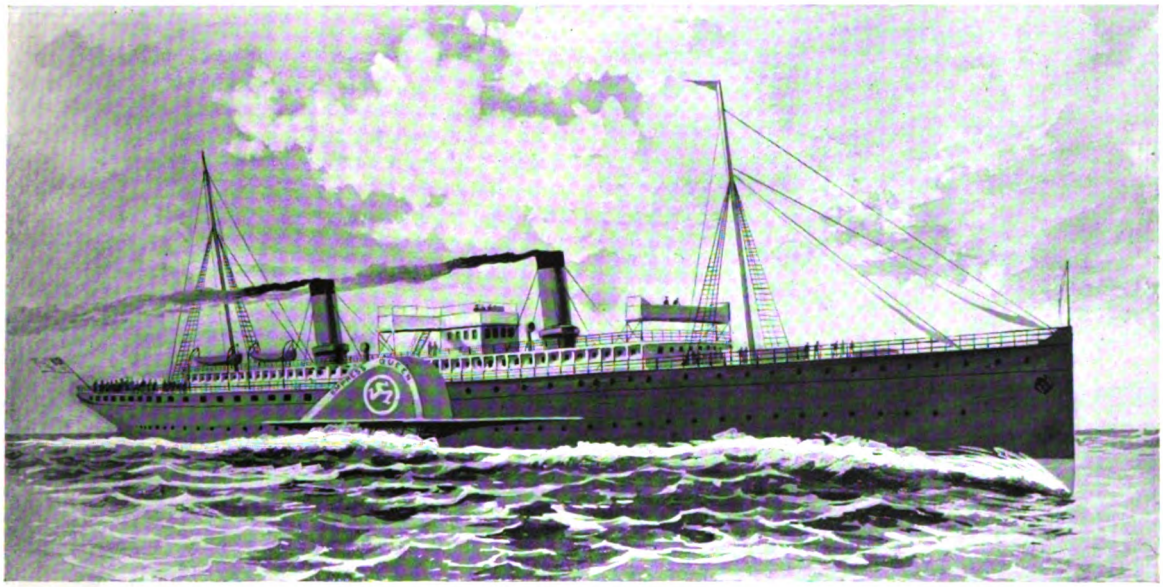
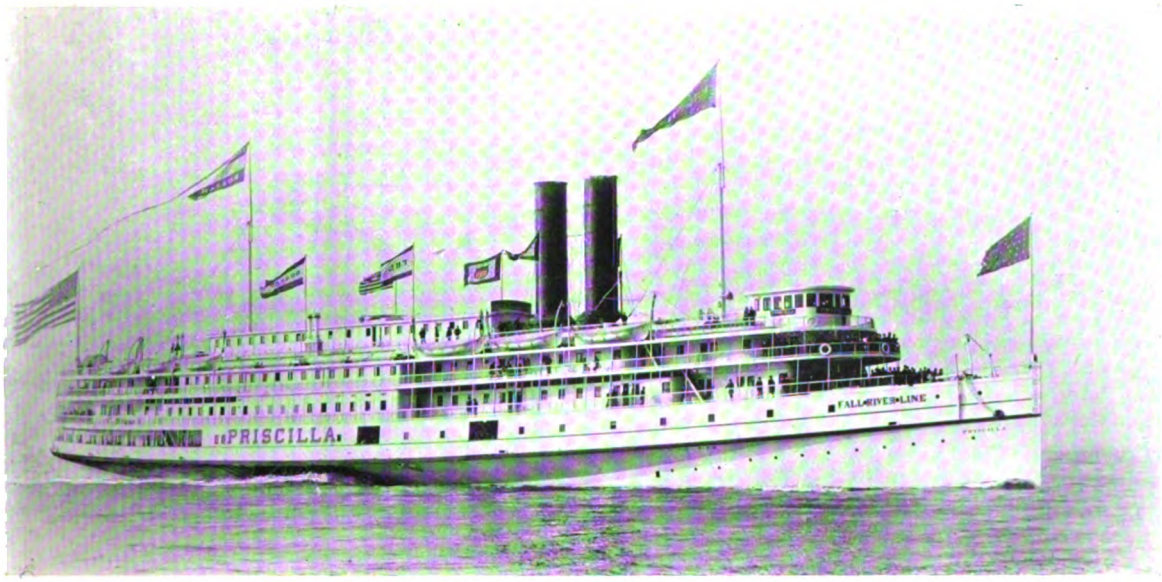
end of the boiler-room right aft to the end of the first-class cabin, with buoyant seats running the entire length, excepting a small portion at the after end, which is required for the boats. The stowage of the boats has received special attention, so as to allow of immediate launching if necessary. The promenade deck covers about three-fourths of the length and the whole breadth of the vessel, and being unobstructed by anything but absolute necessities, such as captain's house and bridges, it in every way justifies the title, promenade. The bridges which surmount the promenade deck are placed, one at the foremost extremity for navigating purposes, and the other between the funnels, and extending from sponson to sponson. From both of these bridges the bow and stern rudders are controlled by means of wheels connected with independent steam steering gears placed below on the engine-starting platform. A hand-screw steering apparatus is also placed in reserve aft in case of emergency. Docking and engine telegraphs are provided on each of the bridges. A complete installation of electric light is fitted on board, including deck and embarkation lights, etc., all on the most improved system. A steam capstan windlass is fitted for-



ISLE OF MAN STEAM PACKET EMPRESS QUEEN.



FALL RIVER LINE PADDLE STEAMER PRISCILLA.

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ward for working the ship's cables, and on the spar deck aft a powerful capstan is fitted for warping and mooring purposes. A double-acting steam winch is fitted forward for the speedy

GRAND SALOON OF PRISCILLA.

handling of luggage, etc. The vessel will be fitted with compound diagonal surface-condensing engines, the largest and most powerful paddle-wheel engines yet built. There will be three steam cylinders placed side by side, and working on three cranks, the high-pressure cylinder being placed between the two low-pressure cylinders. The high-pressure cylinder is fitted with a piston valve, and each of the low-pressure cylinders with flat slide valves, all controlled by the usual double eccentrics and link motion valve gear. The crank shaft is a ponderous piece of machinery. It is built, and together with the paddle shafts is forged of mild steel and bored hollow. The starting and reversing is effected by a large steam and hydraulic engine on the direct-acting principle. The paddle-wheels are made of steel, and constructed on the feathering principle with curved floats. Steam is supplied to the engine by four double-ended boilers arranged in two compartments, one forward and one aft of the engine-room. The boilers are of the multitubular return-tube marine type, each having eight corrugated furnaces, and constructed entirely of steel to Board of Trade requirements. They are adapted to work with Messrs. Howden's system of forced draught, and the necessary fans and engines will be fitted to supply air to the furnaces. The vessel will have two funnels, and will be rigged as a schooner with two pole masts.

AMERICAN STEAMSHIP PRISCILLA.

The Priscilla is the largest boat of the Old Colony Steamboat Company's fleet, better known as the Fall River Line. The contractors for the vessel were the W. & A. Fletcher Co., Hoboken, N. J., who built the engines. The hull was constructed by the Delaware River Iron Shipbuilding and Engine Co., Chester, Pa. She was launched August 10, 1893, and went into commission June 25, 1894. Her dimensions are: length, 440 ft. 6 in.; breadth, 93 ft.; depth, molded, 21 ft. 6 in. Her register tonnage is 5,398 tons, and her engines develop 9,000 horse power. The vessel runs between New York and Fall River, Mass., taking the inside course, a distance of 181 miles, which is covered at an average speed of 18 miles. She is built of mild steel, with a double hull,

MIRROR IN GRAND SALOON OF PRISCILLA.

which extends well above the water line. This space is divided into 52 water-tight compartments, and there are 9 additional water-tight compartments between the inner hull and the main deck, 61 in all. The boat is very substantially stiffened throughout. In the salons and cabins,

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concealed by the elaborate ornamentations and joiner work, steel trusses spring from the decks at the bases of the wall and span in unbroken arches overhead. There are four decks running the entire length, main, saloon, promenade, and

	Launched.	Length.	Breadth.	Depth, Molded.	Tonnage, Gross.	I. H. P.	Passenger Accom.	Dining Room Accom.
Empress Queen	March, 1897	375 ft.	83 ft. 6 in.	25 ft. 6 in.	2,000	10,000	560	124
Priscilla	August, 1893	440 ft. 6 in.	93 ft.	21 ft. 6 in.	5,398	9,000	1,500	325

COMPARATIVE TABLE DIMENSIONS, ETC., PADDLE STEAMSHIPS EMPRESS QUEEN AND PRISCILLA.

hurricane deck. There are 361 staterooms for passengers, and 32 for the ship's officers, and in the dining room 325 passengers can be seated at one time. The main gangway for passengers connects with the quarter deck used as a smoking room or lobby, which is immediately forward of the dining room on the main deck. The various offices of the ship are situated here, together with the barber shop, cigar store and other conveniences. The floor is laid in mosaic, and the woodwork is rich mahogany, the walls relieved with beautiful groups in bas-relief. The windows of the dining room command a splendid view on three sides. The decorations of this room and the table features, which make a very artistic ensemble, can be seen in the accompanying illustration. Aft of the dining saloon there are private dining rooms and ladies' cabins. From the quarter deck a wide staircase leads up to the grand saloon. A view of this is here shown. This saloon rises up through the promenade deck, and is lit by side lights under the span of the roof. The furnishings and decorative work are artistically magnificent, a blending of rich reds and white and gold, with polished metal work. A specimen of the ornamental detail is shown in the illustration of the engine room bulkhead or-

DINING ROOM ON MAIN DECK OF FALL RIVER LINE STEAMSHIP PRISCILLA.

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namentation. The promenade deck gives communication to the upper cabins in the grand saloon and provides a wide stretch of level deck for passengers, fore and aft and along the sides, except amidships, where the engine trunk is carried up. On the hurricane deck there is a splendid promenade space running all around. On this deck the officers' rooms occupy the center, and the boats are carried at the sides. In the front is the pilot house, fitted with the newest navigating apparatus. The propelling engine is a double inclined compound, with two high-pressure cylinders 51 in. dia., and two low-pressure 95 in. dia., by 11 ft. stroke. The wheels are of the feathering type, 35 ft. dia. and 14 ft. wide, with 13 buckets each. These are 5 ft. by 14 ft. by 1 in. thick, and the dip, at the mean draught of 13 ft., is 8 ft. In design the engines are very massive. The main journals are 27 in. dia. and 30 in. long, and the crank journals are 21¾ in. dia. The engines average 22 revolutions at full speed. Two surface condensers are fitted with a total of 15,868 square feet cooling surface. There are four circulating pumps with 12 in. discharge, and engines 10 by 10 in. Steam is supplied at 130 pounds pressure by 10 Scotch boilers, 14 ft. by 14 ft. 6 in., fitted with Serves tubes. These boilers have 850 square ft. grate surface, and 35,620 square ft. heating surface. There are also two superheaters fitted, 8 ft. 8 in. inside dia. and 12 ft. long. Blowers with 7 in. by 10½ in. engines are fitted so that forced draught can be used. There are two smoke stacks, 9 ft. 6 in. dia., and with tops 100 ft. above the keel line. The bunker capacity is 200 tons, and fresh water tanks, holding 9,210 gallons, are used. The engine room is well supplied with the most improved auxiliaries. The electric light plant is extensive, supplying current to 1,900 lamps. The Priscilla has accomodation for 1,500 passengers and 800 tons of freight, and has a crew of 206 men. She is capable of a much higher rate of speed than that usually attained, but as the run is at night it would cause passengers inconvenience in having to get up too early if she made faster time.

The American Society of Mechanical Engineers held the spring meeting at Hartford, Conn., commencing May 25. At the opening session an address of welcome was read by the Mayor of Hartford. Many valuable papers were read during the meeting, visits were paid by the members to large works in the vicinity, and an excursion was made to the stone quarries at Portland.

On a recent eastward voyage the Cunard liner Lucania covered 2,939 miles in 5 d. 14 h. 54 m., at an average of 21.80 knots. The mean speed for two days' steaming was 22.33 knots.

The Navy Department has selected the U. S. Cruiser Brooklyn to represent the United States at the Diamond Jubilee of Queen Victoria.

STEAMSHIP VIBRATIONS WITH RECORDS OF RECENT OBSERVATIONS.—1.

BY PROF. W. F. DURAND.

The subject of steamship vibrations has within a few years received a very considerable amount of attention from marine engineers and naval architects, and from others similarly interested in the modern development of the science and art of marine construction. The great increase in the ratio of power developed to weight of hull has brought with it the possibility of setting up vibrations of a character so severe as either to preclude the possibility of realizing the power desired, or to threaten the dismemberment of the vessel when pushed to full power conditions.

In order to understand the existence of these vibrations we must first remember that the typical modern ship, as a whole, may be considered as an elastic steel structure, and like any other elastic structure it may be thrown into systems of vibration in a variety of ways. For purposes of general illustration, the ship may be represented by an elastic steel rod, say two feet long and one-quarter inch square section. If in addition special weights, such as bits of lead, are secured along the rod more or less irregularly so as to represent the more important weights of the ship, such as boilers, engines, etc., the analogy will be still more complete, and if still further the cross section of the rod were modified here and there to represent the varying amount of resisting moment in the material of the ship, the representation would be still more satisfactory. Suppose such a system taken in the hand and held horizontally at the middle. Then we know that by shaking it gently up and down the rod will be thrown into vibratory motion in the same direction. In such case the middle and the ends will at any instant move in opposite directions, while between the middle and each end there will be an intermediate point nearly at rest. Such points are called nodes, while the remaining points form portions called loops. Such a mode of vibration is one of the simplest into which such a system can be thrown, and is the type of the principal mode usually found in a vibrating ship. Vibrations of higher orders may exist in such a rod, and in the ship of which it is the illustration. The complete examination of these systems would be beyond the scope of the present article, but those interested may refer to a paper by Herr Otto Schlick published in the transactions of the Institution of Naval Architects for 1894.

In making such an experiment we should soon find that for a given amount of energy expended, a greater and greater result will become apparent as the distinct impulses are more nearly timed in accord with the natural period of vibration of the system with which we are dealing. Another illustration of this well-known phenomenon is found in the excessive vibrations which may be developed even in a massive bridge by the proper tim-

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ing of the impulses as by a body of men marching across in step and in time with its own natural period. As the timing of the impulses becomes less and less in accord with the natural vibrations of the system, the result for the same amount of effort is less and less, until when the divergence becomes very great, the result for a small effort becomes quite inappreciable. If, however, the impulses are so timed as to be an even sub or over multiple of the proper number (as one-half or twice the number) somewhat greater disturbance may be expected than with intermediate values. These are usually, however, of small relative importance, and with ships we are chiefly concerned with the fundamental system of vibrations. In using the weighted rod as an illustrative vibrating system, we must remember that the ship is a vastly more complex structure, and that instead of being supported at the middle or at the two ends or at any definite number of separate points, it is provided with a distributed support ready to yield in any and all directions. The ship is therefore more complex and less constrained than the representative system, and hence the more ready to respond to periodic disturbing impulses. In fact, we find that any such elastic system is ready to respond to the application of any periodic or regularly timed impulse, and the response will be the more notable, other things being equal, the more nearly the disturbance is timed in accord with the natural period of vibration of the system. We shall recur at a later point to some further features of the relation between the ship and the disturbing impulses, but for the present it will be sufficient to remember that a periodic impulse applied almost anywhere on the ship is sufficient to set up a system of vibrations, more or less severe according to the circumstances of the case.

Let us now look for the possible causes of such periodic impulses. We naturally turn to the engine as the initial source of effort on the ship, and there find a ready response to our inquiries. There are in the engine three principal sources of such periodic impulses: Unbalanced reciprocating parts, unbalanced cranks, and unbalanced pressures on the guides. These we will briefly examine in order.

First let us consider what is taking place during the first part of the down stroke. The net pressure on the piston is down. An equal net pressure acts upward on the cylinder as a whole. Now if the piston and other reciprocating parts were at rest, or were moving with a uniform velocity, there would be no force involved in their acceleration or retardation, and, omitting friction, the net vertical load on the piston would be ultimately transmitted as a vertical pressure on the crank shaft, and by it, to its bearings, and thus to the engine bed-plate. The pressure of the steam would thus introduce two equal and opposite forces, one lifting up on the bed plate by way of the columns, the other pressing down by way of the main pillow block bearings. There would thus be simply a tendency to bend the bed plate, sides up and center down, but no tendency to force it as a whole down on to its seating, or to lift it bodily upward. In the actual case, however, the piston and other reciprocating parts are moving with an accelerated velocity. This means that force is being spent to bring about this acceleration, or in other words, that they are absorbing, so to speak, a part of the net pressure on the piston, and only the remainder is transferred down to the connecting rod and thus to the bed plate. It thus results that there is actually during this part of the stroke, a lesser force down than up, and hence the result is a net lift on the engine and bed plate as a whole, and hence a decreased load on the engine seat and ship in this locality. The result is thus equivalent to a sudden upward impulse applied to this part of the ship's structure. During the latter part of the down stroke, the reciprocating parts are moving with a retarded velocity, and they resist, so to speak, this retardation, and hence transmit down to the connecting rod a greater load than that due to the net piston pressure. In this part of the stroke, then the downward load is greater than the upward, and the result is a thrust downward from the engine upon the seating and structure of the ship. In a similar manner we may see that during the first part of the up-stroke the result is downward, and during the latter part upward. It follows, therefore, that while the piston is in the upper part of the cylinder, whether moving up or down, there is a net lift on the bed plate and seating, and when in the lower part there is similarly a net thrust downward. We have thus a regularly varying effort alternating up and down with every revolution of the engine, and quite sufficient to account for much of the trouble whose causes we are discussing.

Turning now to the cranks we find the webs and pin revolving in circular paths about the shaft axis, while a considerable part of the connecting rod is moving in a path very nearly the same. Due to centrifugal force there is a constant pull outward radially. When the crank is on the upper part of its path, the general resultant of this is upward, and when on the lower part it is similarly downward. The engine bed plate and seating are furthermore so rigid in a transverse direction, that the horizontal resultant of these forces is unable to produce any significant effect, and so far as results are concerned, the centrifugal forces may be considered as giving rise to an alternating up and down impulse, adding, as is seen, its influence to that of the unbalanced parts considered above. This simple analysis does not take account of the angular acceleration of the connecting rod, but is sufficiently complete for the purpose in view.

The third cause of disturbing impulses is found in the periodically varying side thrust on the guides. With the engine turning in any given direction, this is always directed the same way,

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and varies from nothing at the two ends, to a maximum at or near the middle. There is thus a side thrust or impulse varying from nothing to a maximum twice in a revolution, and thus tending to cause a vibration in the columns, and a bending or rocking of the bed plate on its seating. These impulses are twice as rapid as those previously considered, and hence their separate effects are not wholly additive. The influences due to the more rapid impulses will, however, enter in and become absorbed by those previously referred to, modifying them more or less according to circumstances. In addition to these principal sources of disturbing impulses, others of less importance are found in the movement of the main slide valves, the eccentrics, the auxiliary machinery, etc.

There is still another cause of disturbance applied at another part of the ship and which we may now briefly consider. The crank effort is continually variable throughout the revolution to an extent depending on the circumstances of the case. Due partly to this, but more especially to the irregularities in the wake or stream in which it works, the propeller moves with a variable angular velocity, and meets with a varying resistance throughout the revolution. Generally speaking, any given blade meets with its maximum resistance when in the upper part of its path, and with its minimum when in the lowest part. There is also a more or less pronounced impulse or blow communicated to the stern post as the blade passes nearest it, especially if the clearance between the two is small. Due to these causes the stern of the ship receives a series of irregular periodic impulses which combine with, and modify the results of those previously discussed.

As a result of the indefinite capacity for vibration possessed by the ship in virtue of its elastic and irregular structure, and of these irregular but periodic impulses, the entire ship is thrown into vibratory movement more or less complex and irregular according to circumstances. Illustrations of the character of such motion are to be seen in the accomyanying diagrams, to which special reference will be made at a later point.

The immediate results of this motion are twofold: Discomfort to the passengers and personnel, and a greater or less amount of additional periodic stress thrown on the structure of the ship. The tendency of the latter, if the vibrations exist in excess, is to shake loose riveted and bolted joints, and generally to loosen and disorganize the entire structure. Under such conditions, the decks and bulkheads vibrate like so many drumheads, while the entire structure is rising and falling alternately at the ends and middle. With the existence of such vibrations in excess it may well result, that either the vessel will receive serious injury, or else that the full power and speed cannot be obtained. It may also be pointed out, that such vibrations are in themselves a direct absorbent of power. If the ship were entirely surrounded by air, the power absorbed, once the vibrations developed, would be but small. As it is, however, the ship is partially surrounded by water, and this is a medium most admirably adapted to the absorption of the energy of such a vibrating system. We may, in fact, imagine the energy of the vibrations constantly streaming away into the water, its place necessarily taken by fresh energy derived from the engine as the source of power. While, doubtless in any ordinary case, such loss would be small in amount, yet its existence should not be overlooked.

We will now turn briefly to a description of the diagrams shown in the plate. These were taken from the screw steamer Maine, of the Providence and Stonington Lines, on the regular trips of March 31, and April 1, 1897. The principal dimensions and particulars of this ship are as follows:

Length over all	310 feet
Length on water line	302 "
Beam over guards	60 "
Beam at water line	44 "
Draft (mean)	11 ft. 6 in.
Displacement	2,200 tons

Cylinders, 28 in., 45 in., and two 51 in.; by 42 in. stroke.
Propeller 4 bladed, 13 ft. 6 in. diam. by 18 ft. 6 in. pitch.

The cylinders are in the sequence: High, intermediate, first low, second low, from forward aft. The high and intermediate cranks are opposite, as are also the two low pressure cranks, and the two pairs are at right angles. There are two decks continuous except for the space for the engine and boiler trunk. The upper of these, the saloon deck, carries the superstructure containing the staterooms and is covered by a light shade deck arched in the transverse direction. Above the saloon deck forward, is located an additional superstructure, carrying the dining room and café, and above this the pilot house. Below the main deck aft, is a half deck for berthing second class passengers. The hull is of steel and is apparently well built throughout.

Turning now to the plate, Figs. 1 to 12 inclusive, show diagrams of the vertical movement at points on the main deck from aft forward, distributed as nearly uniformly as possible. No. 1 was over the propeller and No. 12 by the windlass. The number of revolutions was about 100 per minute, and the number of principal vibrations is, of course, the same. No. 1 shows at this instant an interference effect evidenced by the partial suppression of every other vibration. A few seconds earlier on the same diagram, the character was similar to that shown in No. 2. Nos. 5 and 6 show the successive growth of another form of interference effect. Each principal vibration in the downward direction on the diagram is modified by an impulse in the opposite direction, until at No. 6, the original vibration of 100 per minute, has been cut up into a double number as shown. In No. 7 the secondary impulse has fallen again to an unimportant feature, and the main vibration of 100 per minute is again established. In Nos. 9, 10, 11, and 12 are shown

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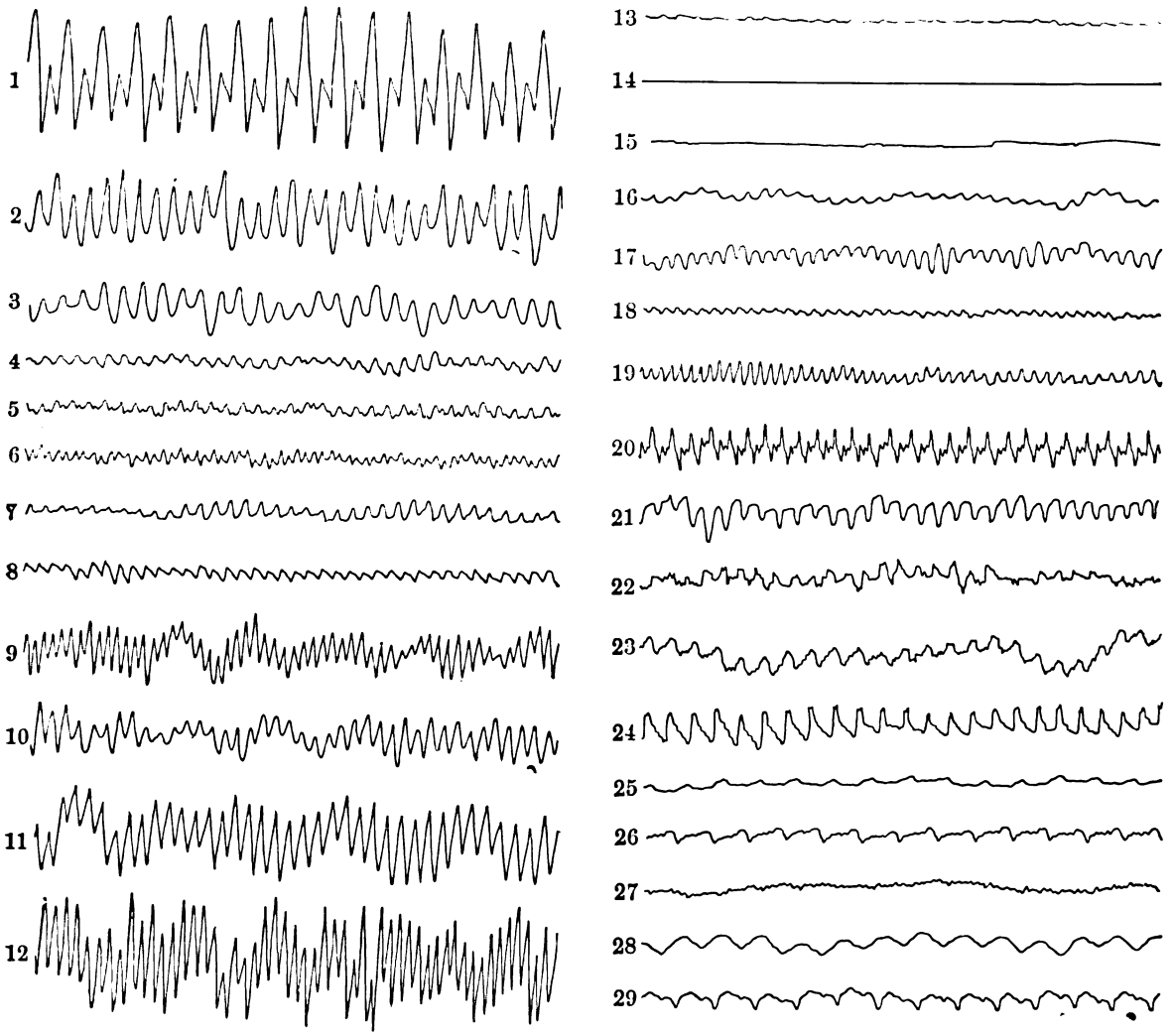

RECORD OF OBSERVATIONS OF VIBRATIONS ON PROVIDENCE AND STONINGTON LINES, S.S. MAINE.

effects due to vibrations of longer period or to irregular disturbances due either to the waves, or to cumulative influences arising from the minor vibrations themselves.

In No. 13 we have the transverse vibration at the same location as for No. 1. Nos. 14 and 15 are similarly related to Nos. 7 and 12. The transverse vibrations are thus seen to be quite negligible. The longitudinal vibrations were found to be quite as small. These vibrations were all taken from the decks. As we shall see later we find pronounced transverse and longitudinal vibrations from other members of the ship. No. 16 was taken from the dining room situated on the upper promenade deck forward. Nos. 17 and 18 were taken from the main keelson, the former at the after end near the stern tube, and the latter about 30 ft. forward of this point No. 19 was taken from the lower engine room floor. No. 20 was taken from the same location as No. 2, when backing, but not at full power. The much greater irregularity of the movement is plainly indicated. Nos. 21 and 22 are from the top of a steam radiator in the after end of the main saloon. No. 21 shows the vertical component and No. 22 the transverse. Nos. 23 and 24 were taken from the head of the after low pressure cylinder. No. 23 shows the vertical component and No. 24 the longitudinal. Similarly Nos. 25, 26, and 27 show the vertical, longitudinal, and transverse components from the same place with somewhat less power. Nos. 28 and 29 show similarly the vertical and longitudinal components from the head of the Intermediate Pressure cylinder. A series of diagrams taken from aft forward on the saloon deck gave results similar to those shown for the main deck, but of somewhat lesser amplitude. These diagrams show that the central portion of the ship was very free from vibration, and that the movement for the most part consisted of vertical oscillations of the ends. In other words the points referred to as nodes in the first part of the article, have drawn together and include substantially its central body of the ship. This seems to be in accord with general experience with ships of moderate size, so far as the point has been observed. In the next article various means for the prevention of vibrations will be considered.

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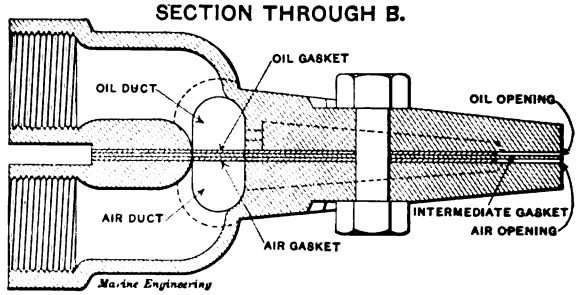
RESULTS OF LIQUID FUEL EXPERIMENTS IN THE U. S. NAVY.—1.

BY J. S. ZERBE.

In September, 1895, Commodore George W. Melville, Engineer-in-Chief of the Bureau of Steam Engineering, U. S. N., authorized the Experimental Board of Naval Engineers to conduct a series of exhaustive tests to ascertain the relative values of coal and liquid fuel, and to determine the efficiency of the latter for naval purposes. Numerous tests have been made in different countries, during the past twenty years, to utilize liquid fuel, but the results have been so varied that no reliable data was obtainable. While many of the experiments showed high evaporative values, the question of efficiency was left unsettled. High evaporation is not always the best criterion. While the relative evaporation of oil and coal may be as two to one, it does not follow that the efficiency is in the same ratio. Time is an element which must be considered. A system of using liquid fuel which will evaporate the largest amount of water within a given time is the most efficient, because the difficulty is and has been to "force" a boiler with oil as with coal. It is in this particular that former experiments have failed for marine purposes. The firing could, of course, be forced, but to do so would invariably produce smoke, cause blistering of crown sheets or tubes and require an excessive use of oil. Such has been the result of naval tests heretofore, and when the Consolidated Gas Fuel Co., of New York, first presented the question of making official tests of its system to Chief Engineer Melville, he was doubtful concerning the value of this fuel for naval purposes, principally for the reasons set forth.

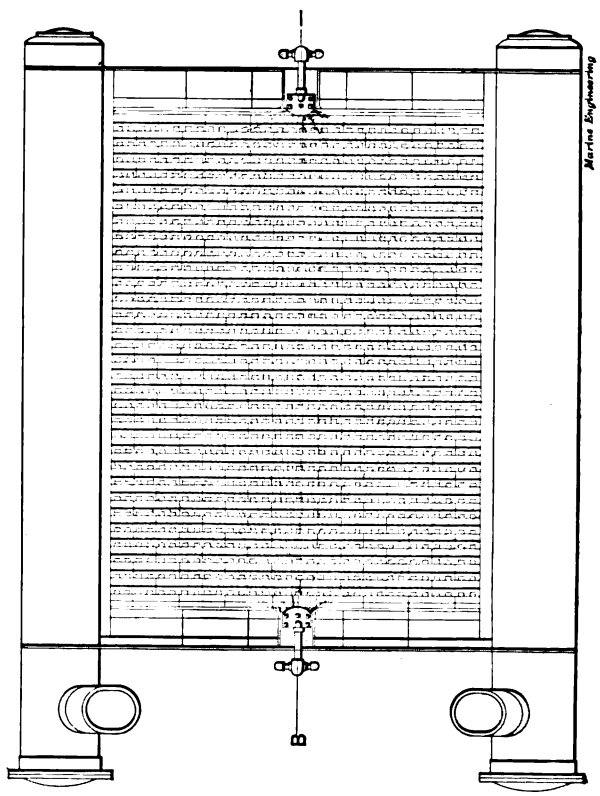
In order to give some idea of the system it will be necessary to point out a few of the distinguishing features employed in the old systems of using fuel oil, and, primarily, it should be observed that there seems to be a general impression among all who have, heretofore, entered this field, that the atomizer or burner is the essential feature in the process of burning oil. The burner is, simply, a stoker, and while it is true that one burner may stoke better than another, this advantage is a small one when compared with the fire box equipment. A fire box which is not specially equipped to burn liquid fuel will never do good work, however perfect the burner may be. Over seven hundred patents have been obtained for burners, and less than thirty for fire box equipments. This shows most emphatically how vigorously inventors have struggled at the wrong end of the problem, and explains why failures are so common the world over. Furthermore, it may be said that there are two ideas predominant in the minds of liquid fuel experimenters beyond which they seem loth to go. The first is that a candle or barrel shaped flame is essential, and that the flame should be ejected against a baffling wall erected within the fire box. These features are primeval in their character, fundamentally wrong in their operation, and radically deficient in results when applied under any type of boiler.

The essential thing is to perfectly aerate the hydro-carbon gases evolved by the heat of the combustion chamber. Where oil is thrown into



SECTION OF FUEL OIL BURNER.

the heated chamber the gases form rapidly, an immense expansion takes place, and the interior of this conical flame cannot receive the requisite amount of air to produce perfect combustion; hence, owing to the rapid movement of the mass, it passes into the tubes with a large portion of



SECTION OF BOILER OVER GRATE.

unconsumed particles, and thus passes into the flue and out the stack in the form of smoke. At this point the inventor sought by a new expedient to arrest the flame, break it up and produce a mixing operation by introducing a baffling wall. The flame in striking this wall would natu-

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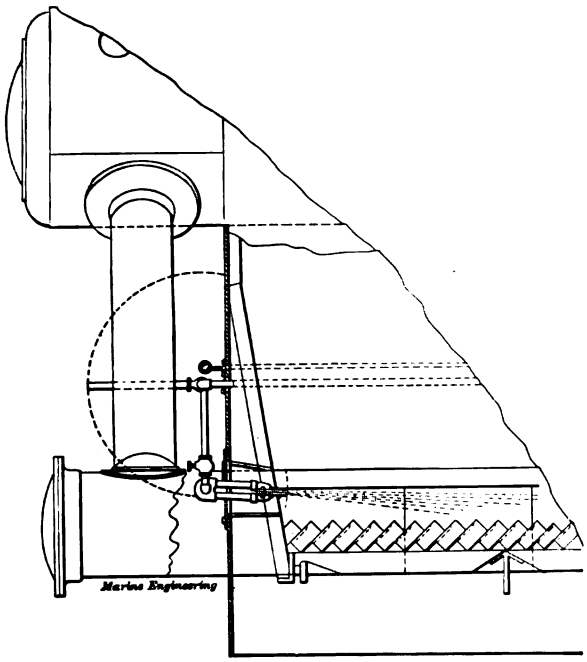


POSITION OF BURNER WITH REFERENCE TO GRATE.

rally be deflected upwardly, so that it would strike the boiler sheet or tubes, and thus form a zone of intense heat at the wall, which has been found to be very destructive to the boiler. But this is not all. The wall naturally diminishes the size of the combustion chamber, which should in all cases be larger than for coal, in preference to being smaller. There is also a very serious defect in the old style, so called oil equipments, in the manner of admitting air to the fire box. In all cases it has been customary to admit air in a mass, either around the burner or into the fire box at one point through the grate surface. This results in producing a disagreeable noise; cold air is admitted to the boiler, and when so supplied, in a body, the desirable mixing operation is not accomplished to produce a steady, uniform flame, of great intensity. Some inventors provide conduits and retorts for heating air, while others provide a vaporizing chamber for the oil; but all these attempts to utilize auxiliary mechanism or contrivances outside of the fire box to prepare the fuel and air are needless expenditures of force, make the system complicated and difficult to regulate, and are useless expedients when compared with the "direct conversion" system which contemplates the taking of the fuel and the oxygen in the natural state, and producing complete combustion within the fire box itself. Manifestly such a system is much simpler in construction, more easily operated, and less expensive

The construction of such a system, therefore, contemplates the following features:

First—The fire box must perform the entire operation.

Second—The grate surface must not be decreased in area.

Third—The heating surface of the fire box should not be diminished.

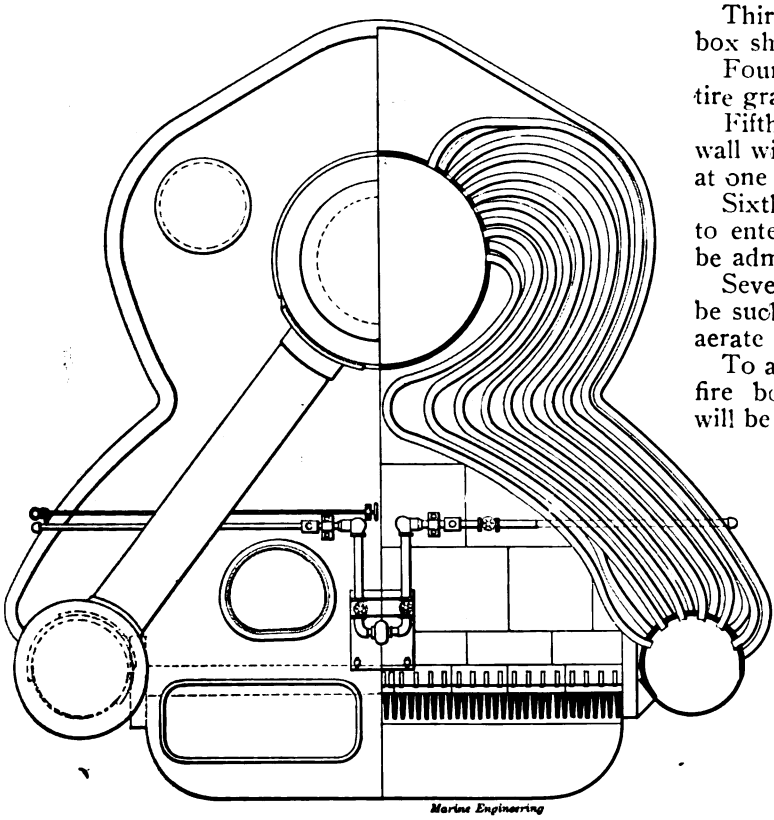
Fourth—The flame should cover the entire grate surface.

Fifth—There should be no retarding wall within to produce a great zone of heat at one point.

Sixth—Cold air must not be permitted to enter the fire box, and it should never be admitted in a mass.

Seventh—The shape of the flame should be such that the air will freely mingle and aerate the entire mass.

To accomplish this a very simple form of fire box construction was provided. It will be seen by reference to the illustrations that the entire grate surface is covered with a single layer of specially prepared fire brick. This brick has, on one side, ducts, partially across one face, and these brick are nested against each other at an angle of 45°, so that when the bars are covered small ducts are formed through this bed over the entire surface. This bed formation has several very important functions. It breaks up the air, so that it enters the fire box in small jets, and after the burner has been in operation a short time the entire bed is heated up to incandescence,



METHOD OF FITTING FUEL OIL ATTACHMENTS.

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thus heating the air as it passes through the ducts. The bed, when in this state, also acts as a substitute for an incandescent bed of coal, giving out radiant heat to the boiler, and thus economizing fuel. The burner or atomizer is specially adapted for use with this brick bed, as it is designed to throw a fan-shaped spray, thus causing the flame to cover the entire bed, so that when the subdivided jets of air come up through the ducts in the bed, every part of the flame has its requisite supply of heated air, which readily commingles with the hydrocarbon gases.

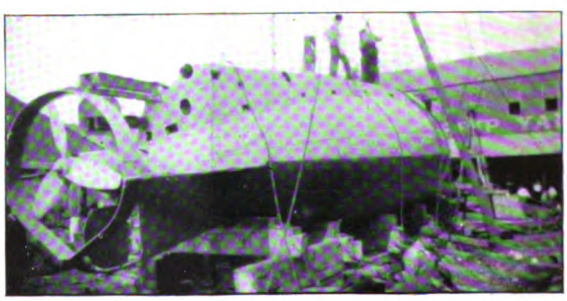
The burner is simple in construction, being composed of two castings, an upper and lower part, substantially similar in construction, the upper part having an oil supply connection and the lower part an air or steam inlet. These inlets terminate in open transverse channels, from which radial grooves extend to a point near the forward circular end of the burner. The contact faces of these ducts are dressed off, and between them are placed three copper gaskets or diaphragms, the intermediate one of which has its forward edge extending to the circular rim of the burner, while the upper and lower gaskets have V-shaped notches cut therein, the bases of which communicate with the radial ducts. These gaskets are composed of No. 30 gauge copper or even thinner material, and as the oil and the compressed air, or steam, are forced through the small interstices, the V-shaped openings permit the liquid and the steam to expand horizontally, producing a continuous sheet at the mouth of the burner. The two parts and the gaskets are held together by means of bolts. This form of burner has several distinct advantages. In cutting the gaskets a greater or less number of these ducts can be brought into action, or the flame can be horizontally disposed over a wide or narrow area, dependent on the shape of the fire box. By using thicker or thinner gaskets the capacity can be increased or decreased, and as the oil channel which supplies all the ducts is horizontally disposed the burner can be directed at any angle desired without having an undue flow of oil to the central or the side ducts. In the torpedo boat tests compressed air was used. The illustrations show a water tube boiler designed for the new 140 ft. torpedo boats which are now in process of construction, and will give a comprehensive idea of the system, although the tests were conducted with a Mosher water-tube boiler.

The experiments were conducted in the New York Navy Yard on one of the Government torpedo boats, fully one year being consumed in the entire series of experiments, nine months of which were devoted to liquid fuel and three months to coal tests on the same boat. The experiments were conducted by the Experimental Board of Naval Engineers, composed of Chief Engineers Lewis J. Allen, Prest., George Cowie, Jr., and H. S. Ross.

Holland Submarine Torpedo Boat.

The accompanying illustrations show the submarine torpedo boat, designed by John P. Holland, before and during the launching at the Crescent Shipyard of Lewis Nixon, at Elizabethport, on May 17. The boat is of the familiar cigar-shape, 55 ft. long and 11 ft. dia. in the widest part. It is very substantially built, the skin plating being 1-2 in. mild steel. This motive power consists of a 50 horse power Otto gas engine driving

a single screw, while traveling on the surface, and an electric motor taking current from storage batteries, when the boat is submerged. Steering is effected by two rudders, one vertical for steering on the surface, and the other horizontal to regulate the depth at which the vessel will be maintained. Entrance to the boat is effected through the turret which surmounts the structure, and which is telescopic, and fitted with glass lights for observation. The interior of the vessel is more roomy than one would imagine from a view of the exterior. In the forward end the tanks for compressed air are carried, and beneath the floor plates, the storage batteries. Aft of this much space is given to the engine and dynamo and



fittings, the floor here being at a lower level. The fighting powers of the vessel are supplied by an ordinary Whitehead torpedo apparatus pointing forward, an 8 in. aerial torpedo gun with a range of 1 1-2 miles in the same direction, and a submarine gun which will eject an 80 pound high-explosive shell aft. Another boat of this type, to be propelled by triple screws is building at Baltimore. For these particulars and the photographs of the vessel we have pleasure in acknowledging the courtesy of C. A. Morris, who is interested in the success of the boat.

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INFLUENCE OF MOIST STEAM IN THE ECONOMY OF A STEAM TURBINE.*

BY D. S. JACOBUS.

There has been an impression in the minds of some engineers that the presence of a small amount of moisture in the steam used by a steam turbine might tend to improve the efficiency by increasing the density of the jets of steam that impinge against the buckets of the wheel. This would not follow from the theory of the steam turbine if the friction of the turbine and of the steam in the passages, and other losses, are not included, but as these form a large factor in the economy, and must be taken account of in any theoretical discussion of the effect of moisture, the problem becomes complicated, and it is difficult to predict, from theory, what the exact effect will be.

Tests were therefore undertaken, in which the amount of moisture in the steam was accurately determined, by starting with dry steam and condensing a portion of the same in the steam main leading to the turbine. The heat required to condense the steam, so as to form the moisture, was determined, and from this heat the weight of moisture was calculated. The power developed by the turbine was measured by means of a prony brake. The total amount of water consumed by the turbine was measured by condensing the exhaust in a surface condenser, and from this total amount the moisture in the steam on entering the turbine was deducted to obtain the weight of dry steam used by the turbine.

The conclusions arrived at are:

First.—The average dry steam consumption, or the total water consumption, less the weight of entrained water in the steam entering the turbine, was about the same for either dry or wet steam.

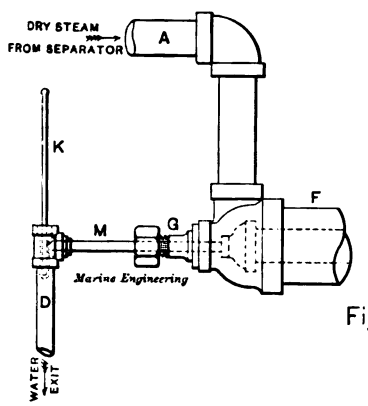
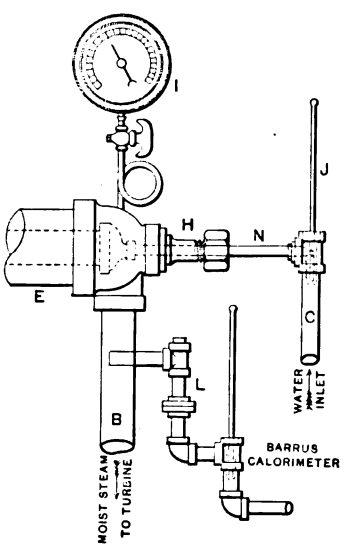


Fig. 2



Second.—This may only hold for wheels of a similar type running under similar conditions.

The pressure of steam in the tests was about 95 lb. per sq. in. above the atmosphere. The

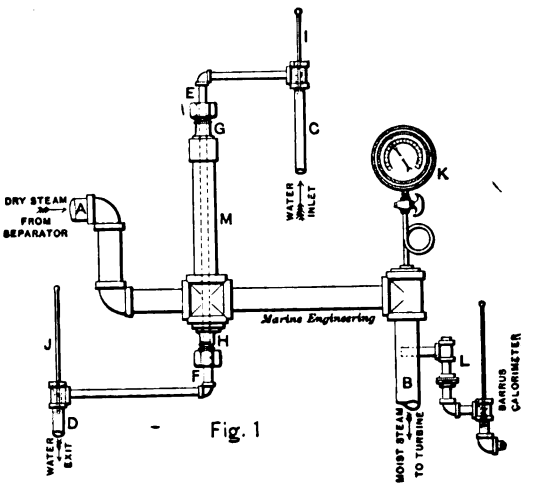


Fig. 1

turbine wheel was 8 5-8 in. dia., and ran at about 10,200 revolutions per minute.

At 14 1-2 brake horse power the dry steam consumption was about 68 1-2 lb. per hour per horse power, with either dry steam or steam containing moisture.

The weight of dry steam per hour per brake horse power, in comparative tests, is given in Table I. There were sixteen jets of steam impinging on the turbine wheel. These were in groups of four each, and the governor was arranged so that it cut off the steam from one or more of the four groups of jets. Each jet had a width of 1-8 in., measured in a vertical direction to the plane of rotation of the turbine wheel. The smallest cross-section of each jet was about 0.009 sq. in., and the largest 0.015 sq. in. The jets issued at an angle of 67 deg. to the radius of the wheel.

The turbine wheel was of steel. It was 8 5-8 in. dia., and was geared so that the driving shaft ran at 1-9 of the speed of the wheel. The prony brake was placed on the driving shaft. There were 46 buckets in the turbine wheel. The width of the passages in the wheel, measured at right angles to the plane of rotation, was 3-16 in. The area of the cross-section of the passages in the wheel was about 0.032 sq. in. The angles made by lines tangent to the two sides of a bucket in the wheel with a radius passing through the bucket averaged 52 deg. on the inside of the wheel and 69 deg. on the outside.

The devices employed for condensing a por-

* Read at the meeting of the American Society of Mechanical Engineers, Hartford, May, 1897.

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tion of the steam in the pipe leading to the steam turbine are shown in Figs. 1 and 2. The device shown in Fig. 1 was employed for the tests when there was a small percentage of moisture, and that shown in Fig. 2 for the tests when the percentage of moisture was made greater.

The steam from the boiler first passed through a separator (not shown in the figures), and from the separator entered the pipe marked A in Figs. 1 and 2.

In Fig. 1 cold water entered the pipe C, and flowed through the pipe EF, which was enclosed in the steam space in the vertical pipe M. The half-inch pipe EF passed through two stuffing-boxes G and H. The water flowing through the pipe EF was heated, and condensed a portion of the steam. The amount that the water was heated was measured by means of two thermometers, I and J, placed in mercury wells. The weight of water circulated through the pipe EF was determined by collecting it in a large tank placed on a pair of platform scales.

The arrangement of piping shown in Fig. 1 was used in tests Nos. 7, 11, and 13. The pipe M and the pipe EF were made longer in tests Nos. 11 and 13 than in No. 7, so as to increase the amount of steam condensed.

Tests Nos. 15, 17, and 18 were made with the arrangement shown in Fig. 2. The vertical pipe M shown in Fig. 1 was dispensed with, and a horizontal length of 2-in. pipe was used for condensing a portion of the steam, in place of the vertical length of 1-2 in. pipe. The horizontal 2-in. pipe was placed inside of the 4-in. pipe FE, and is shown by dotted lines in Fig. 2. The inlet water passed through the 1-2 in. pipe N, and the exit water passed out through the 1-2 in. pipe M. The pipes N and M passed through the stuffing-boxes H and G. The temperature of the water was measured by means of the thermometers J and K.

The total amount of steam entering the turbine, together with the entrained water in the same, was measured by condensing the exhaust of the turbine in a surface condenser.

In the tests with dry steam no water was circulated through the cooling pipes, and the steam was found to be dry by means of the Barrus calorimeter, marked L in Figs. 1 and 2, or to contain less than 1-5 per cent of moisture, which is considered as dry steam in the present investigation.

The tests with wet and dry steam were made alternately, so as to eliminate errors due to any possible change in the turbine.

The piping shown in Figs. 1 and 2 was coated with hair felt. The exhaust pipe leading from the turbine was of a large diameter, and the back-pressure of the exhaust steam was practically that of the atmosphere.

The prony brake consisted of two hemp ropes passed around a pulley about 12 in. dia., in which were fastened two flanges so as to form a hollow rim. The ropes made a full turn about the pulley, and were fastened to a wooden frame,

TABLE I.

STEAM CONSUMPTION PER HOUR PER HORSE POWER FOR A STEAM TURBINE WITH DRY AND WET STEAM.

TESTS WITH DRY STEAM.			TESTS WITH WET STEAM.			
Number of Test.	Horse Power by Prony Brake.	Steam per Hour per Horse Power.	Number of Test.	Percentage of Moisture in Steam.	Horse Power by Prony Brake.	Steam per Hour per Horse Power = Total Water Consumption Less Weight of Entrained Water in Steam Entering the Turbine.
1	2	3	4	5	6	7
9	15.17	67.5	7	3.7	15.08	68.7
12	15.25	67.6	11	4.7	15.13	67.1
14	15.17	71.9	13	4.6	15.16	69.8
16	13.53	67.5	15	18.5	13.64	66.4
19	13.47	68.3	17	16.8	13.41	70.7
			18	18.3	13.43	69.5
Average.	14.52	68.6			14.31	68.7

TABLE II.

TESTS OF A STEAM TURBINE WITH DRY AND WITH WET STEAM.

Number of Test.	Date of Test.	Percentage of Moisture in Steam.	Load on Prony Brake, in Lbs.	Steam Pressure in Lbs. per Sq. In. above Atmosphere.	Average Time for Prony Brake-wheel to make 1,200 Revolutions, in Seconds.	Revolutions of Prony Brake-wheel per Minute.	Horse Power by Prony Brake.	Dry Steam Consumption = Total Water Consumption Less Weight of Entrained Water in Pounds		Duration of Tests in Minutes.
								Per Hour.	Per Hour per Horse Pow'r	
1	2	3	4	5	6	7	8	9	10	11
	1896.									
1	Oct. 13	0	82.0	90	62.07	1,160.0	9.66	680.2	70.4	60
2	" "	0	124.0	92	64.12	1,122.9	14.15	973.5	68.8	60
3	" 14	0	41.5	91	60.15	1,197.0	5.05	404.2	80.0	60
4	" "	0	170.0	112	64.83	1,110.6	19.18	1,257.0	65.5	10
5	" 15	0	118.6	125	62.75	1,147.4	13.83	892.0	64.5	60
6	" "	0	147.8	130	63.83	1,128.0	16.94	1,157.0	68.3	60
7	" 16	3.7	132.0	94.5	64.00	1,125.0	15.08	1,036.1	68.7	60
8	" "	9.3	43.0	92	60.00	1,200.0	5.24	410.7	78.4	40
9	" "	0	132.0	94.3	63.66	1,131.0	15.17	1,023.9	67.5	35
10	" "	0	43.0	95.0	59.90	1,202.0	5.25	382.2	72.8	25
11	Nov. 16	4.7	132.0	92.7	63.82	1,128.2	15.13	1,014.8	67.1	60
12	" "	0	132.0	91.6	63.32	1,137.1	15.25	1,031.0	67.6	60
13	" "	4.6	132.0	95.0	63.70	1,130.3	15.16	1,058.3	69.8	45
14	" "	0	132.0	93.0	63.63	1,131.5	15.17	1,091.1	71.9	20
15	1897.									
	Jan. 15	18.5	118.5	93.2	63.54	1,133.1	13.64	905.1	66.4	60
16	" "	0	116.5	93.6	62.98	1,143.2	13.53	913.5	67.5	60
17	" "	16.8	116.5	94.9	63.53	1,133.3	13.41	948.6	70.7	25
18	" "	18.3	116.5	94.0	63.45	1,134.7	13.43	834.0	69.5	50
19	" "	0	116.5	92.9	63.25	1,138.3	13.47	920.2	68.3	40

Column 7=1,200×60÷Column 6.
Column 8=Column 4×Column 7×0.0001016
Column 10 Column 9÷Column 8.
Revolutions of turbine wheel per minute=Column 6×9, because the gear reduces in the ratio of 9 to 1.

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which rested on a pair of platform scales. It was found necessary to play water on the outside of the brake-wheel, to prevent the ropes from burning, as well as to keep water on the interior of the rim. At first great difficulty was experienced in making the prony brake work uniformly under the severe conditions, but all difficulty was eliminated when it was found that a cake of ordinary soap, held against the face of the wheel when running, would cause the brake to work smoothly.

TABLE III.

DATA AND CALCULATION OF PERCENTAGE OF MOISTURE IN THE TESTS WITH WET STEAM.

Number of Test.	Steam Pressure in Lbs. per Sq. In. above Atmosphere.	Weight of Water circulated through Cooler, in Lbs. per Hour.	Temperature of Cooling Water, in Deg. F.		Weight of Steam condensed by Cooler, in Lbs. per Hour, or Entrained Water in Steam.	Steam and Entrained Water in Same from Condenser, in Lbs. per Hour.	Dry Steam per Hour in Lbs., or Total Water Consumption Less Weight of Entrained Water.	Percentage of Moisture in Steam.
			Initial	Final				
1	2	3	4	5	6	7	8	9
7	94.5	455.0	57.2	133.3	39.4	1,075.5	1,036 1	3.7
8	92.0	940.5	56.2	95.8	42.3	453.0	410.7	9.3
11	92.7	607.0	50.1	122.8	50.2	1,065.0	1,014.8	4.7
13	95.0	730.7	49.9	111.7	51.4	1,109.7	1,058.3	4.6
15	93.2	1,699.0	35.7	142.2	205.8	1,110.9	905.1	18.5
17	94.9	1,474 0	36.0	150.3	192.0	1,140.6	948.6	16.8
18	94.0	1,787.2	36.0	139.2	209.9	1,143.9	934.0	18.3

Column 6=Column 3 (Column 5—Column 4)÷latent heat of one pound of steam at pressure given in Column 2.
Column 8=Column 7—Column 6=Column 9, Table II. Column 9=Column 6×100÷Column 7.

The results of the tests in detail are given in Table II. Table III gives data and calculations of the amount of moisture contained in the steam entering the turbine.

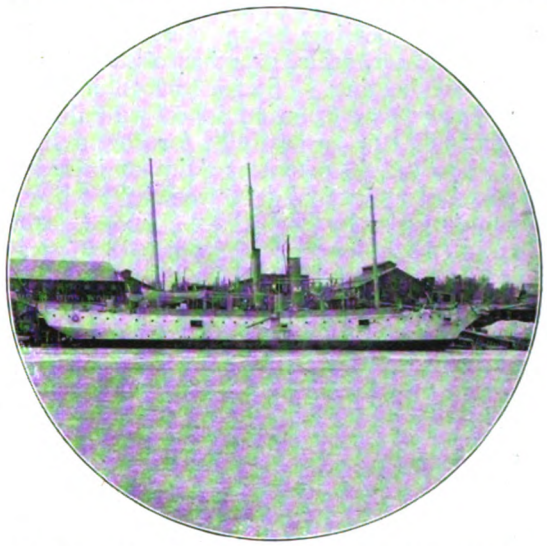
The program for the International meeting of the British Institution of Naval Architects, which is to celebrate the Queen's Diamond Jubilee, has been announced. The meeting will be opened by the Prince of Wales at the Imperial Institute, Tuesday, July 6, and will last throughout the week. The forenoons will be devoted to the reading of papers, and discussions, and visits will be paid to the yachting and fisheries exhibition at the Imperial Institute, also to the London docks, the Thames Iron Works, and to the Southampton docks and Portsmouth naval dockyards. During the week following the meetings those who desire to accept invitations will visit Wm. Denny Bros. shipyard at Dumbarton, where the famous experimental tank will be examined, and the Fairfield Shipbuilding and Engineering Co., at Govan, on the Clyde. Visits also will be paid to the great Armstrong Works at Newcastle-on-Tyne and to Palmer's yard at Jarrow, noted for phenomenally fast torpedo craft. It is expected that several American delegates will attend the meeting, as a special invitation has been extended to the Society of Naval Architects and Marine Engineers.

Gunboat Mistaken for Yacht.

A nice compliment was unintentionally paid the Bureau of Construction and Repair of the Navy, and Lewis Nixon, a few days ago, by one of the leading New York dailies. The former

N. Y. NEWSPAPER CUT REPRODUCED.

drew the plans for the gunboat Annapolis, and it was at the latter's yard that the vessel was built. The newspaper referred to published an illustration, which is here reproduced, of a "new steam yacht in course of construction on Staten Island



U. S. S. ANNAPOLIS, STATEN ISLAND SOUND.

Sound." The other illustration is a reproduction of a photograph of the same "yacht." It was a natural mistake, however, for the artist to make, as when viewed from a distance the gunboat Annapolis is like a handsome pleasure vessel. This is not only because the contour of the hull is graceful, but on account of the three slender masts. These will carry a fore and aft spread of canvas, so dear to the heart of the jack-knife sailor.

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IMPROVED APPARATUS.

New Roller Thrust Bearing.

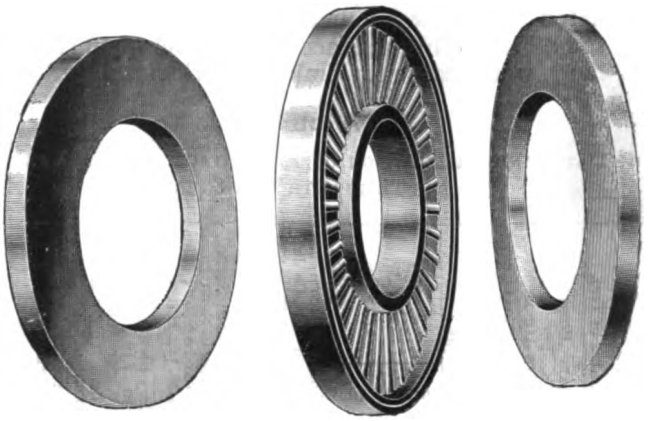
A new thrust bearing for steamships, shown in the illustration, is the invention of Frank Mossberg, who is well known in engineering circles as a pioneer along the lines of anti-friction bearings. His end-thrust invention, like those of his roller bearings, has been perfected through a long series of carefully executed experiments carried out by practical application to various classes of machines of many forms of construction. The bearing in itself is of the simplest form of construction, consisting of a series of conical rollers held in a cage, which is slipped over the shaft, upon which is fastened a cast iron collar. Between this collar and the cage is interposed a steel disc, one side of which is faced off at an angle to correspond to the conical rollers in the cage. There is a similar disc on the other side of the cage which rests between the cage and a thrust block. When the shaft revolves the friction between the two steel discs causes the conical rollers to rotate and carry the cage with them, making a perfect roller bearing in the form of an end thrust. This style of bearing has been in use for over two years on a number of different styles of machines having a heavy end thrust, such as worm shafts on elevators and wire drawing machinery. A unique application of this bearing has been made to turbine wheels, the turbine being suspended from the bearing in place of the customary position at the end of the shaft. The bearing being above the turbine wheel, no water, scale, or other obstruction can get on the bearing. Steam yachts up to 500 horse power have been equipped with this new bearing and run successfully for the past two years, showing, the patentees claim, an increase in the speed of upward of 5 per cent. The bearing is manufactured by the Mossberg & Granville Mfg. Co., Providence, R. I., which is at present equipping a number of boats.

Ball Bearings for Steam Vessels.

The use of ball bearings to relieve the friction of thrust in the propeller shafts of small vessels is a feature of recent engineering practice. The Ball Bearing Co., of Boston, Mass., has devised a bearing of the sort which is here illustrated. It will be noticed that the balls are conveniently held in a brass cage and that they revolve between two hardened steel washers. All the parts are accurately ground true. The arrangement as shown is made double to take the thrust going forward or reversing. It is made also to take it in one direction only. The details of construction are shown in the smaller cut. It will be noticed that the balls are staggered, so as to travel in different paths and prevent grooving. These bearings have already been applied to engines developing from 3 to 100 horse power, with good results. The device is patented.

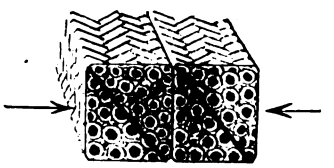
New Sectional Piston-Rod Packing.

A. W. Chesterton & Co., of Boston, Mass., have applied for a patent and lately put on the market an improved piston rod packing, which is especially designed to supersede the old style square flax packing. The new packing is made

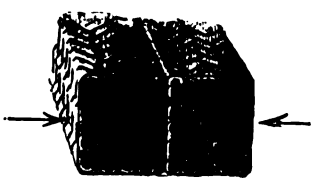


ROLLER BEARINGS FOR SHIPS.

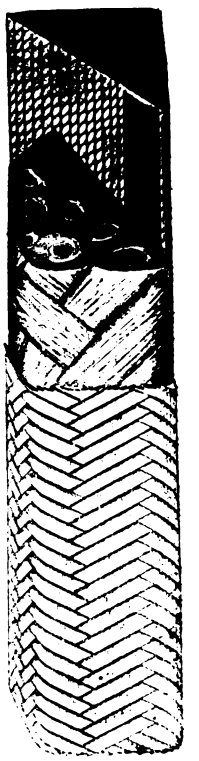
sectional, as shown in the accompanying cut. It is claimed for this packing that it has more "life" and "give" than the old style, and consequently allows compensation for wear. The ordinary square flax packing, shown in the cut, being



NEW STYLE.



OLD STYLE.



SECTIONAL FLAX PACKING.

placed one turn over another, requires a very considerable pressure on the gland to give lateral compression on the rod. A round packing when

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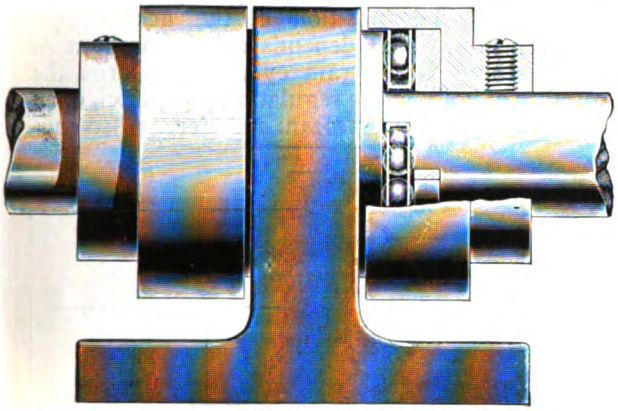
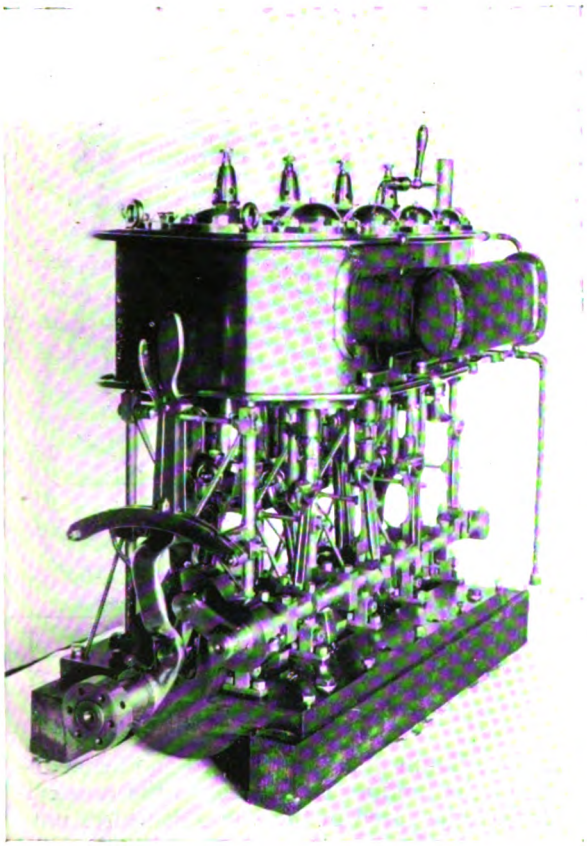
used would easily become flattened from the pressure of the gland, and would shape itself to the box, but this advantage has heretofore been lost in the use of the square packing, which, for hydraulic use and in many other places, is necessary. It can be seen by reference to the sections



BALL BEARING FOR PROPELLER SHAFT.

here shown that a very slight pressure on the gland will expand the packing sufficiently to hold it perfectly tight, and as the packing becomes



SMALL HIGH SPEED ENGINE.

worn it can still be forced on to the rod, and used long after the ordinary square flax would have to be renewed. This, of course, means economy in the cost of the packing and economy in labor, as it will not have to be renewed so often, a saving of friction on the rod, and a tighter joint. It has besides the braided flax feature a section of rubber-back hydraulic packing, which gives elasticity and expansion, also firmness, to the packing, and allows the two sections to easily slide by each other.

High Speed Engines for Small Vessels.

A compact, almost clocklike, four-cylinder triple expansion engine is here illustrated as built

DETAIL OF BALL BEARING.

by the Lockwood Manufacturing Co., of Boston, Mass. The cylinders are 3 in., 4 1-2 in., and two 4 3-4 in., with 3 in. stroke. The materials used in its construction are phosphor bronze, steel, and cast iron, the latter very sparingly. The cylinder casting, pistons, guides, crossheads, bed plate, and main bearings are phosphor bronze. Steel is used for crank shaft, valve spindles, standards, and moving parts. The piston rings and valves are cast iron. Piston valves are used throughout. These are 1 1-2 in., 2 1-8 in., and two 2 1-4 in. dia. Steam is taken at the ends and exhausted in the middle. The valve motion is obtained from four cranks on the auxiliary shaft, which is run by two fast and loose gears from the main shaft. For reversing, the angle of advance is obtained by rotating the two loose gears with the ordinary lever. The motion is quick and sure and takes up very little room. As the engine is run at very high speed, care has been taken to balance all the moving parts as nearly as possible. To effect this, the high pressure and intermediate pressure cranks are placed opposite each other and their plane is at right angles to that of the two low pressure cranks, which are also opposite each other. This same arrangement is made in the valve shaft. This balances well and makes no dead center. The weight of the piston, crosshead connecting rod, and moving parts of each cylinder is the same, and through it adds slightly to the weight of high pressure piston, it helps in steadiness when running. The engine is designed for steam at 200 to 250 lbs., and has been run light up to 1,180 revolutions per minute, and that with only a couple of small lag screws to hold it. In the boat for which it was designed an average of 650 revolutions with 190 lbs. has been maintained. The air and feed pumps are run by gearing from the main shaft at about one-third the number of revolutions of the engine. The feed pump is 1 1-4 in. by 2 in. stroke, and the air pump

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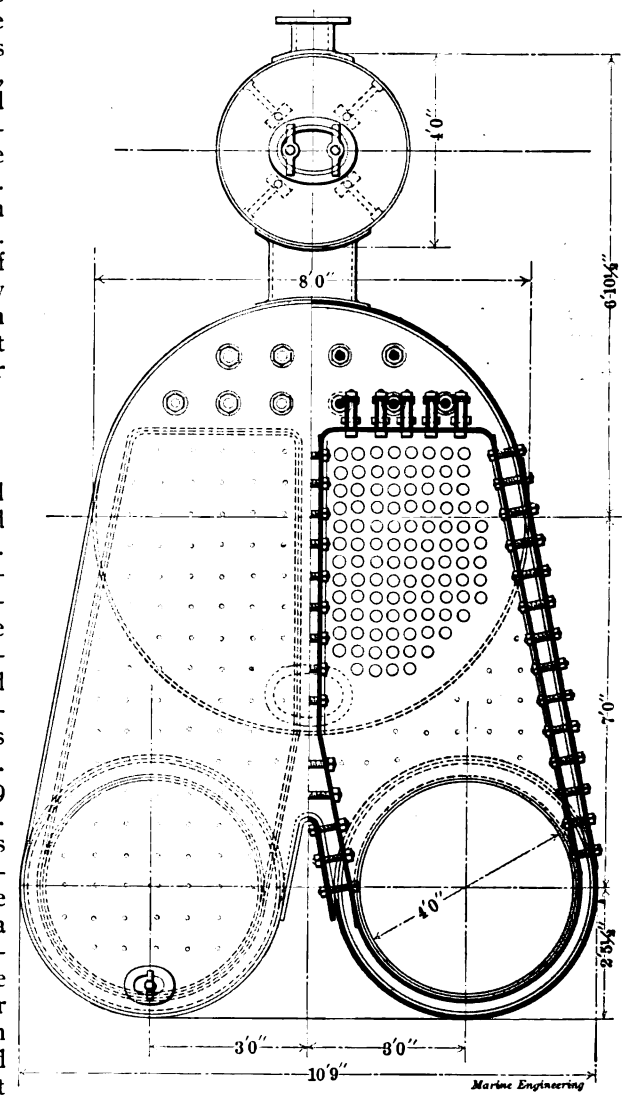
is 2 1-2 in. by 2 in. stroke. The workmanship throughout is excellent and the finish very fine. The whole engine was finished bright and the steel parts nickeled with a dull surface.

A New Type of Marine Boiler.

The illustration shows a new boiler for marine or stationary purposes recently built by Kling Bros., who are the inventors and patentees. The features of this boiler are its compact form and great heating surface, having the same amount of heating surface, with one-third less shell than the ordinary Scotch boiler, and producing all the heating surface possible. The furnaces of this boiler, being placed below the shell of the boiler, with a shell or water-jacket outside and connected to the boiler at the front and rear end of the furnaces, is said to give a perfect circulation, the boiler having the same water space all through. These boilers are built to any size required, with one or more either corrugated or plain furnaces. The illustration will clearly show the design of this boiler. The firm would be pleased to show a boiler of this description, of 40 horse power, in operation, to any one interested in this line, at their works, Kling Bros.' Machine and Boiler Works, 287 Hawthorne avenue, Chicago, Ill.

Pressure Pumps and Accumulators.

The illustrations of vertical pressure pump and steam accumulator show the plant which is fitted in duplicate in U. S. S. Iowa, by Henry R. Worthington, of Brooklyn, New York, for operating the turret mechanism and for the ammunition whips. The compactness of the apparatus will strike the reader who appreciates the value of this feature in the confined spaces aboard ship. Each set of pumps and accumulator, together with connections occupies a floor space 10 ft. 6 in., by 9 ft. 6in., and 15 ft. vertically. The pumps have steam cylinders 29 in. dia. with 10 in. plungers and 18 in. stroke. The accumulators have 25 in. steam cylinders with 10 in. plungers and 36 in. stroke. The accumulator steam cylinder has no ports or valve and the ram cylinder is similar to that of a weighted accumulator. Steam at a fixed pressure, acting on the steam piston exerts the force on the ram which in the ordinary accumulator is secured by weights. The ram passes through two stuffing boxes, one in the steam cylinder and the other in the ram cylinder. The former is not tightly packed as its only office is to prevent the leakage of exhaust steam which is let into the back end of the cylinder to keep hot the cylinder below the piston. The supply of steam to the pressure pump is regulated in this wise:—The regulating pipe consists of a polished perforated pipe, which at one end is connected to an opening through the center of the accumulator steam cylinder head and passes longitudinally through the center of the accumulator steam piston into the interior of the ram casting, the joint between this pipe and the steam piston being made by a long self-adjusting sleeve. The steam supply to the pressure pump is taken from the interior of the accumulator steam cylinder through the holes in the regulating pipe, thence through the steam cylinder head to the pump, the holes in the regulating pipe being distributed spirally throughout its length. The position of the accumulator steam piston, which depends on the amount of water stored in the ram cylinder, governs the number of holes in the regulating pipe which open into the interior of the steam cylinder, and so con-



KLING PATENT MARINE BOILER.

trols the amount of steam supplied and hence the speed of the pump. In service, as the ram cylinder fills, the speed of the pump decreases until just before the steam piston reaches the head of the accumulator cylinder, all the holes in the regulating pipe are shut off by the sleeve in the steam piston, thus stopping the pump. As the water is drawn off from the ram cylinder, the number of holes uncovered in the regulating pipe

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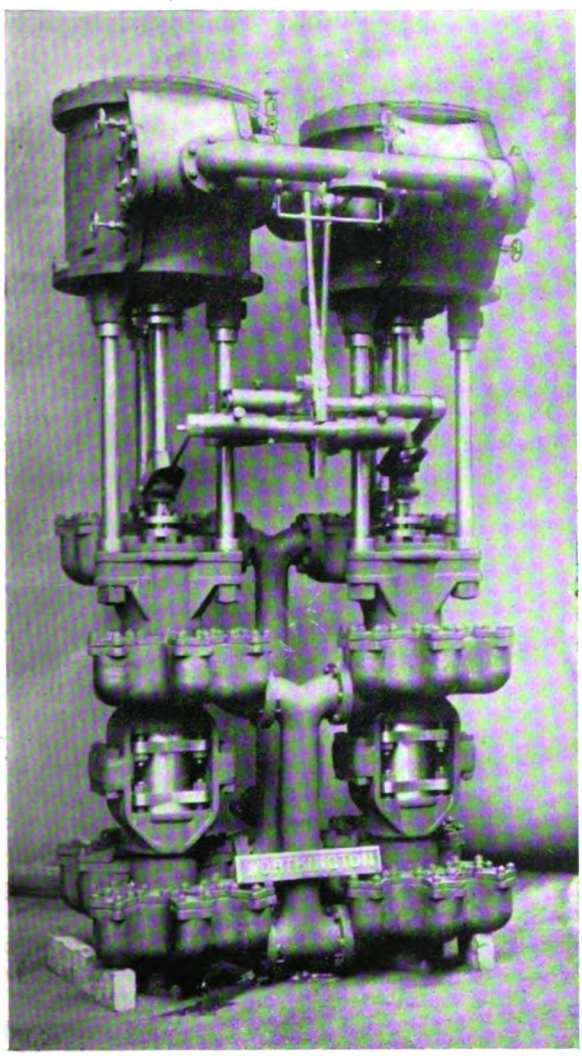
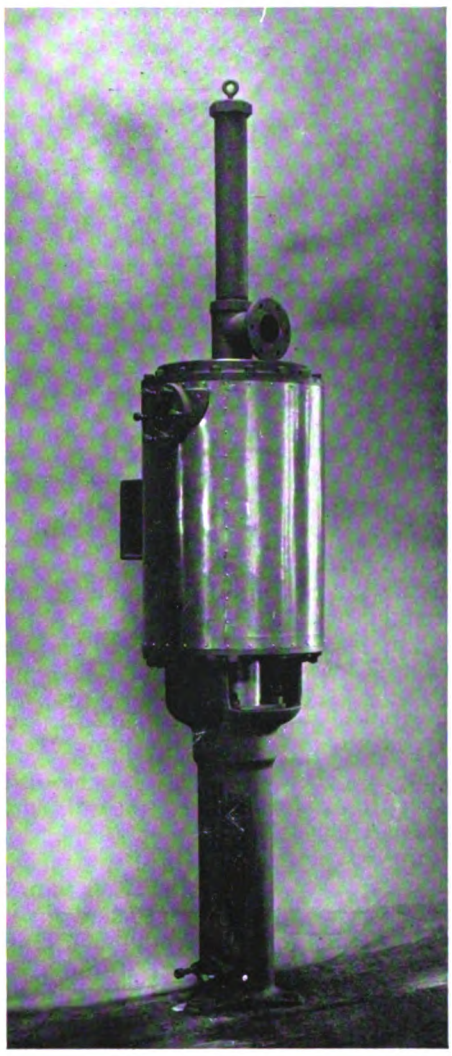
gradually increases until enough are open to drive the pump at its full speed. By this arrangement variations in the speed of the pump are gradual, which is essential to the quiet operation of a heavy pressure pump on a varying consumption of water. The condensation of steam in the regulating pipe and heating of the ram are avoided by a wall of non-conducting material between the inside wall of the ram and the outside of the regulating pipe. The steam in the steam cylinder is maintained at a constant pressure by means of a reducing valve located in the steam pipe just before it enters the cylinder. This valve is set at a pressure not exceeding the minimum pressure carried in the boiler, thus insuring a constant pressure at all times in the cylinder. The advantages of this accumulator over the ordinary weighted accumulator can be readily understood. The most important and marked difference is in the effect on the water pressure. The steam accumulator is not subject to the tremendous shocks and jars due to the momentum of the weights of the weighted accumulator. The moving parts of the steam accumulator being so light that momentum is not a factor, the machine is very sensitive and the variations of the water pressure very slight. As the steam pressure is regulated by a reducing valve this can be very carefully adjusted and varied at will. It will operate satisfactorily when the vessel is rolling in a seaway, when a weighted accumulator would be very irregular.





WORTHINGTON PRESSURE PUMPS AND STEAM ACCUMULATOR IN U. S. S. IOWA.

The steam accumulator will work equally well horizontally or vertically, and can even be suspended from roof beams. The loss from condensation is insignificant, as the steam pressure is constant, the cylinder not being constantly filled and exhausted as in an engine.

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MARINE ENGINEERING

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Letters and other mail matter can be sent to our care and will be forwarded or held until called for, as desired.

Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced if necessary to illustrate the subject, without cost to the writer.

Full names and addresses should be given, but publication of these will be withheld where requested.

In time to come it is not unlikely that the recent meeting of the British Institution of Naval Architects will be referred to as an event of unusual importance in the history of marine engineering. The success of the water-tube boiler in its larger and least understood form, and of the steam turbine as applied to marine propulsion, was announced, with facts and figures in support. Prediction is not the strong point of the sensible engineer, but there are many who foresee radical changes in practice, and at no very distant date. The reports of papers read at the meeting, and discussions which followed, as published in our last and present issue, will inform our readers of the facts as brought out to date. Having these in mind, there are two points in favor of and against the probability of any revolution in engineering methods, which may be noted. The negative one is, that the results which have been had with the water-tube boiler, and rotary form of engine, have been obtained by the application of the most scientific principles, by masters in their profession, and with little commercial regard for expenditure. With such careful designing and adaptation of parts, superior workmanship, and scientific accuracy of manipulation, results out of the ordinary might be expected. For instance, naval stokers may work by the clock, as was done in the now famous trials of the Powerful and Terrible, but the merchant marine engineer is lucky if he can get firemen who will intelligently watch a steam gauge, not to speak of a clock. In support of a probable change, the tendency toward scientific refinements in practice can be mentioned. There has been wonderful advancement in marine engineering in late years, in the way of increased speeds and pressures, accompanied by a steady gain in economy, both of material and fuel. The best practice to-day, with its expansive engines and numerous auxiliaries, calls for a more exact manipulation than was required a generation ago. Then, too, the results of years of theoretical planning and practical working have made commonplace refinements of practice that not long ago would have been considered finical. Thus the engineer to-day is prepared for radical changes which could only have been slowly evolved in the past.

The fire which broke out on the steamship Leona while on a voyage from this port to Galveston, May 8, with fatal results, ought to be a valuable, if a sad lesson. It was a curious coincidence that this disaster should have happened just when every one was congratulating every one else that no such horror as the fatal fire in the Grand Bazar de Charité, Paris, could occur here. The propriety of stowing inflammable cargo in spaces used as passage ways to passengers' quarters is a question which more concerns the executive or commercial departments, than the engineers of a vessel. It is important to the latter, however, in so far as it concerns their possible duties on a voyage; providing facilities for fighting fire. In the Leona disaster the members of the engineering staff acquitted themselves with splendid intelligence. Their work was not simply brave, it was effective. This experience emphasizes the necessity for the engineer, on joining a vessel, to make himself familiar with the auxiliaries, and especially the lead of all pipes and connections of pumping apparatus. It is not only necessary to know the whereabouts of valves and cocks, but to know whether they are in proper working order. Without this exact knowledge, the engineer is helpless during the early stages of a fire, when an adequate water supply would be most effective.

In commenting on the design of Mr. Harrison B. Moore's yacht Marietta, illustrated and described in our April issue, The Shipping World, of London, says "there are several rather striking peculiarities in the internal arrangements of this yacht. For instance, we find a refrigerating chamber placed in the galley, which, in turn, is next the boiler room." As a fact, the galley is not next the boiler room, the engine room coming between, and the temperature in the galley is just as cool as the assertion of our contemporary. The most "striking peculiarity" about the yacht is the convenient manner in which the interior arrangements have been planned.

A very important contribution to the literature on the subject of vibrations on steamships will be found in this issue, the work of Professor W. F. Durand, of Cornell University.

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DISCUSSION ON THE WATER TUBE BOILER.

At the spring meeting of the Institution of Naval Architects held recently in London, a very interesting discussion followed the reading of papers covering the operation of water tube boilers in war ships by Engineer-in-Chief A. J. Durston and Rear Admiral C. C. P. FitzGerald, R. N.

The discussion was opened by J. A. Thornycroft, the famous torpedo boat builder, who spoke favorable on the water tube boiler. He asserted that it suffered less from fouling of the heating surface than the flame tube boiler. Any deposit in the interior of the tubes of the flame tube boiler would obstruct the flow of gases. In the water tube boiler the deposit formed on the outside of the tube, and changes of volume due to expansion and contraction had the effect of cracking off the crust, so that this type of boiler could be effectively used with poor coal. Experiments had demonstrated this. A locomotive boiler and a water tube boiler were tested comparatively. In the former the tubes were blocked by the melting of ashes and other waste, while the water tube boiler continued to steam freely. The speaker believed that the importance of interior examination was overrated. Distilling apparatus was now in general use on ships and there was not much probability of internal deposits being formed. External wasting was the chief thing to be guarded against.

Mr. Moss, who was given the floor, though not a member of the Institution, was very severe in his condemnation of the water tube boiler, and his remarks cause some evidences of feeling. He stated he had had experience with water tube boilers of the Belleville type, which were fitted in the French Messageries Maritimes steamship Ville de Ciotat. Referring to the trouble experienced in the British navy with the Scotch boiler under forced draught, he criticised the design of navy boiler which gave unusuallly long grates. These extended almost into the combustion chamber, and the practical result was that coal was burned under the chamber tops. This naturally was destructive to tubes, which were small and close together. In the mercantile marine, when forced draught was used, the grates were kept shorter than the furnace tube. Referring to his experiences in the S. S. Ciotat, he said, on a voyage from New Caledonia there had been several failures of boilers. In one boiler a tube burnt along the bottom, necessitating the isolation of the boiler until a port was reached, and a new element substituted for the damaged one. In harbor the main engines were started with the effect that the cylinders were filled with water, which came over from the boilers. Another objectionable feature was the quantity of smoke that was incident to the use of these boilers. Strategically, this was a defect that did not occur with Scotch boilers. The most serious troubles he narrated were the necessity for frequent adjustment of the nuts of the bottom connection of the elements, the bending of the bottom tubes, the splitting of the tubes along the bottom, and the liability to draw apart next to the lock-nut unless the lock-nut itself was drawn away from the junction cap.

Sir Edward Reed, after questioning the pertinence of much of the former speaker's remarks, spoke in defense of the value of trial trip performances of naval vessels. These were standard tests, made with good coal by trained stokers in smooth water, and under conditions favorable to the best results. These results became a standard of excellence from which it was the duty of naval officers to make deductions for adverse circumstances, such as a foul bottom, contrary winds, or the like. Trial trip standards were not intended for the use of uninformed persons, but for the information of naval officers and ship designers who had the ability to use them intelligently.

Mr. Grosse, of John Brown & Co., Sheffield, spoke in defense of the cylindrical boiler. When this type of boiler, as designed at the Admiralty, had failed in war ships, under forced draught with a closed stokehold, he regretted that the Admiralty had not tried the Howden system, or his own system of suction draught, with a suitably designed cylindrical boiler, instead of adapting the Belleville boiler. (This had special reference to the equipment of the large British cruisers, Powerful and Terrible.) His firm had fitted mercantile marine ships with cylindrical boilers working at a rate of fuel consumption of 30 lbs. of coal to the square foot of grate, with grates six feet long, and had obtained on voyages around the world 70 to 80 per cent of the efficiency of the coal, and no such troubles as the navy had experienced had been met with. Taking the weights of boilers, of water, and of coal, his firm give could power equal to the water tube boilers of the Powerful and Terrible on the same weights. If the cylindrical boilers were heavier, the difference would be made up in less coal consumption. With a proper system of draught steam could be raised as speedily in Scotch boilers as in water tube boilers.

Mr. Manuel laid stress on the advantage for naval use of the ease with which repairs could be effected to the water tube boiler. What could be done in a cylindrical boiler to repair a furnace? Engineers in the mercantile marine, however, had found advantages and disadvantages on both sides.

Mr. Howden believed that the excessive laudation of the water tube boiler was premature. He referred to the rates of fuel consumption in the trials of the Powerful and Terrible, which were of a most moderate character. The heating surface, too, was nearly double that adopted in the mercantile marine with Scotch boilers and forced draught. The consumption of fuel, on the trials of the cruisers, should have been the lowest possible. The best coal attainable, hand picked, had been used, and other measures of special care had been taken. The coal burnt per indicated horse power per hour was 1.7 lb.; with cylindrical boilers' fired by ordinary stokers, and with common coal, the consumption would have been about 50 per cent better. With the Howden system of forced draught fitted to cylindrical boilers a coal consumption of 1.2 lb. per indicated horse power per hour had been obtained with ordinary coal and ordinary firemen. He believed that the consumption on the cruisers would reach 2 lbs. per indicated horse power per hour, or 70 per cent more than was ordinarily reached with his system. It was taken for granted that the weight of the Belleville boiler was less than that of the cylindrical boiler, but he was prepared to get 25,500 horse power easily on less than 1,100 tons of boilers and water, and to occupy less space than that needed on the cruisers. The speaker referred to various mercantile steamers, including the North-West and North-Land, on the great lakes, in which the water tube boiler was practically a failure.

A. J. Durston, the able Engineer-in-Chief of the British Navy, stated it was a mistake to say the Admiralty had condemned the cylindrical boiler; their position was, they considered the water tube boiler better adapted to the requirements of the navy. As to the question of large and small tube boilers, they considered that for their purposes big tubes were correct for big ships and small tubes for small ships. It had been stated that more firemen were required with Belleville boilers than with cylindrical boilers. Their experience had been the reverse of this, as the complement of stokers had been reduced in ships fitted with Belleville boilers in the proportion of eleven to nine. In working there had been no indication of priming which had been alluded to by one speaker.

Admiral FitzGerald, in reply to the remarks on his paper, an abstract of which was printed in our last issue, was evidently of opinion that the practice of the navy and that of the mercantile marine did not admit of comparison. A point to be remembered was that in a war ship it was necessary to get the boilers under the protective deck, a condition which did not exist in mercantile marine design.

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CORRESPONDENCE.

[We do not assume responsibility for the opinions expressed by correspondents.]

To Prevent Oil Getting into Boilers.

I note in your correspondence department a question signed "Ralph," in which the writer states that several large stationary plants have been fitted with surface condensers, but have been compelled to abandon the use of them, because the condensed water returned to the boilers contained so much oil as to do injury to the boilers, causing the plates to bulge, etc., and he would like to know how this is avoided on vessels which are fitted with surface condensers. This subject of oil in boilers is one on which volumes could be written, as all marine engineers who devote study to the subject have different opinions as to the details of the precautions to be taken, but all are very much awake to the dangers that exist in the indiscriminate use of cylinder oil, particularly as damage caused thereby is very likely to elicit censure from the owner or supervisor of the vessel. As the details of the cases are not stated, it is impossible to give any opinion, but it seems strange that surface condensers, which nowadays are so universally used on shore as well as on vessels, should present such difficulties as to cause them to be abandoned. As modern marine engines are of the vertical inverted type, fitted with piston valves, very little cylinder oil is necessary, and in many cases the main engines as well as the auxiliary engines are run entirely without oil in the cylinders. Where there are heavy slide valves or expansion valves, a small quantity is indispensable, but it is used very sparingly. The average amount which I have noted is about a gallon in 24 hours for every 5,000 I. H. P., including oil for swabbing the rods. Many vessels are fitted with feed water filters, of which there are different varieties and sizes on the market. These do not extract all the oil, but they collect the heavy parts of it which do the damage. In transatlantic liners it is customary to examine and clean the boilers at the end of each trip, while boilers in stationary plants are sometimes allowed to be under steam for one or two months or longer at a time, and no particular attention paid to them at that; offering fine opportunities for the difficulties mentioned to develop. A.

From the Engineer, London.

Sir:—Your correspondent, "Once a Tiffy," refers to sheet lead packing in terms of contumely. It may be worth while to tell him that lead packing has been extensively used in Holland with great success. Two systems are used; in one mitted lead is poured into the stuffing-box round the rod, the bottom of the box is sharply coned, and so is the gland. By screwing down the latter, the lead is compressed against the rod and swelled out in the box. The other system consists in packing the box with sheet lead wedged in. It is essential that the rods should be in good condition and quite true. A turn of Tuck's packing is an improvement. These packings have been used for years by one of the leading Dutch steamship companies. Lead wire and Tuck make an excellent packing. NOW A TIFFY.

Portsmouth.

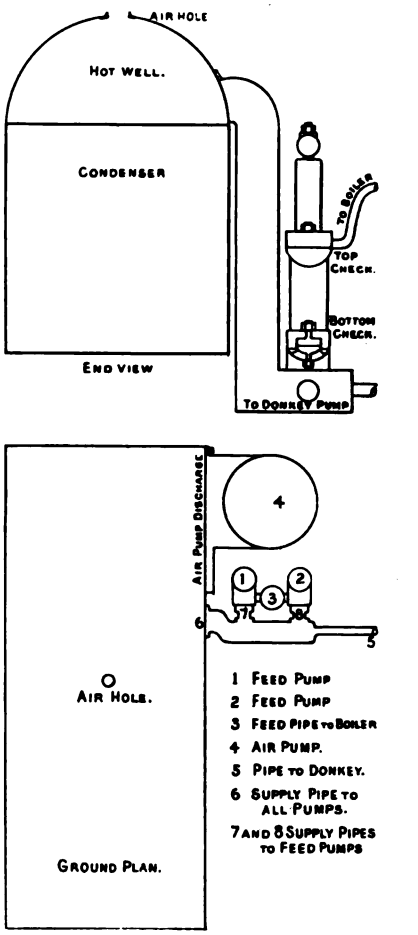
Getting Rid of Excess Feed.

In reply to "E" in your Correspondence in April number of Marine Engineering, would state the "poser" is amply simple. Avoid blowing down, even if saturation reaches 5-32. If all the extra feed was put in the boiler he would get all the salt and scale deposited from all the sea water which came from leak, for blowing down does not prevent deposit. Hence, only use amount needed to keep water level.

A CHIEF ENGINEER.

Remedy for Troublesome Feed Pumps.

From a long and varied experience at sea, I can endorse what "Texas" says about his style of feed pumps being fickle in their action, and if it was at all possible to get an independent feed pump, of the duplex pattern, fitted, he would have no further trouble. From the sketch I would judge that the greater



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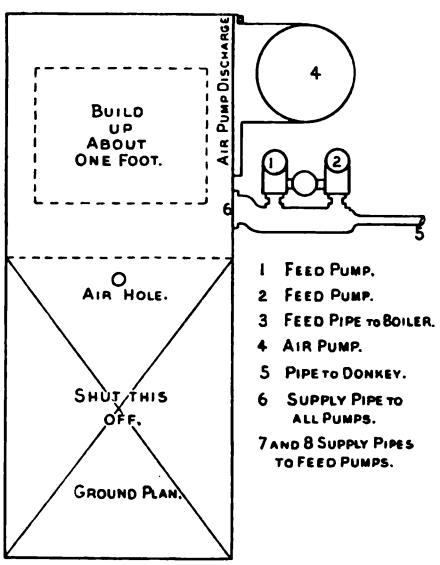

SUGGESTION FOR ALTERATIONS.

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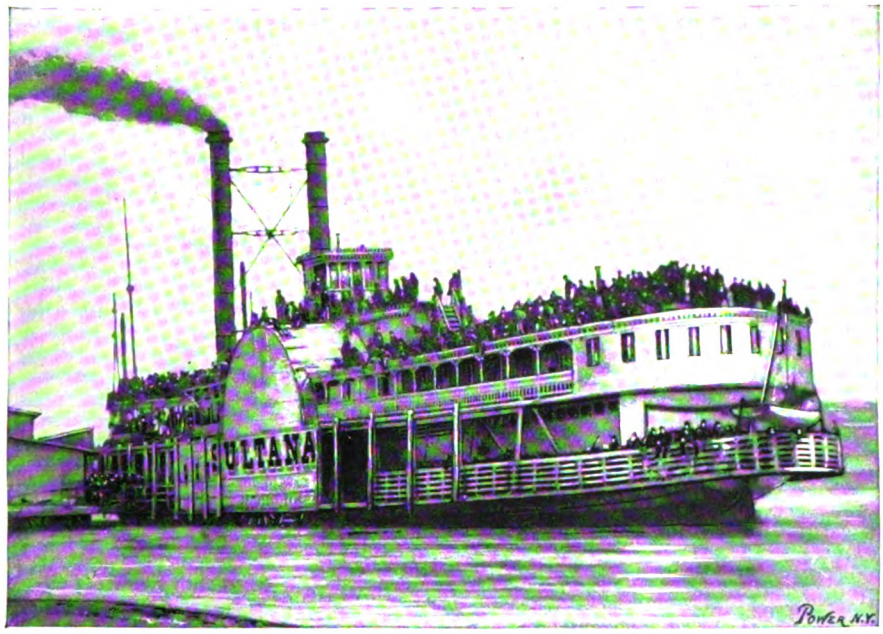
part of his trouble arises from the hot well being too shallow, thus allowing the water at times, when the ship rolls, to uncover the end of the suction pipe and letting air get to the pumps. By shutting off a part of the hot well and building up a foot or two on top of the other part, so that he would get sufficient capacity, he would have a narrow deep well which would always insure the suction pipe being covered with water. C.

I should like to have "Texas" send a section sketch of his feed pump with plunger in its lowest position, and dimensions of plunger and inside of cylinder, whole length, and position of valves, and port from valve chamber to cylinder. I have had his same difficulty with feed pumps, and think with sketch I can suggest a remedy.

F. O. WELLINGTON.

Most Disastrous Explosion on Record.

The most diastrous boiler explosion on record, which occurred on the river steamer Sultana during the civil war, has been the subject of investigation and correspondence by Power. The result has been to bring out an accurate account of this disaster, and a view of the vessel taken shortly before the explosion, which we here reproduce through the courtesy of Power, together with a letter which is explanatory. —Ed.



GOVERNMENT TRANSPORT SULTANA BEFORE THE EXPLOSION.

Editor of Power:—Your correspondent, Mr. Gaston, has "stolen my thunder," but I will add to his communication by sending you a photograph of the steamer Sultana taken ten or twelve hours before the explosion; also a clipping from the Clarion, of Helena, Ark.:

STEAMER SULTANA, CAPT. J. CASS MASON.

This ill-fated steamer was built in Cincinnati, January, 1863; registered 719 tons, and carried 1,300 tons. She was a regular St. Louis and New Orleans packet, and left the latter port on her fated trip April 21, 1865. While at Vicksburg she took on board 2,000 Federal soldiers, just released from rebel prisons in Alabama and Georgia. Her regular passengers and crew numbered some 200, making a total of 2,200 people. At 3 o'clock on the morning of April 27 she had reached a point some seven miles above Memphis, Tenn., when one of her boilers exploded; she immediately took fire and in about twenty minutes was burned to the water's edge. In this, the most terrible of all steamboat disasters, about 1,500 people perished.

A few of the survivors recently had a reunion at Xenia, O. WM. T. MAGRUDER.

Crank Shaft Breakages.

Why is it that crank or line shafts break most frequently in fine weather? An engineer usually associates bad weather with excessive strains in an engine, but from my own observation I would say that the per centage of breakages in storms was small. About the only reason I can perceive for this is that during fine weather a ship develops its greatest power and attains highest speed. In bad weather special attention is given to the engines to prevent racing, and so that excessive strains shall be avoided as much as possible. In fine weather, on the contrary, a ship is pushed to the limit, especially in the case of a calm succeeding a succession of bad days, so that lost time may be made up. Thus the engines are subjected to the heaviest working strains which can be produced, with the natural result that any weaknesses are discovered, some in a decidedly unpleasant way. In fair weather, of course, breakages occur too; for example, in boats trading to the far East, but I speak of the experiences principally in the North Atlantic trade. I should like to hear from other engineers who have given this subject attention. W. I.

A contract has been let by the War Department to the Merritt-Chapman Wrecking Co., for the destruction of the sunken Atlas Line steamship Ailsa, which obstructs the fairway in the Narrows. She was sunk Feb. 29, 1896, by collision with the French liner Bourgogne. The work will be done piecemeal by dynamite. The contract price is $11,975, and the work is to be finished within 90 days.

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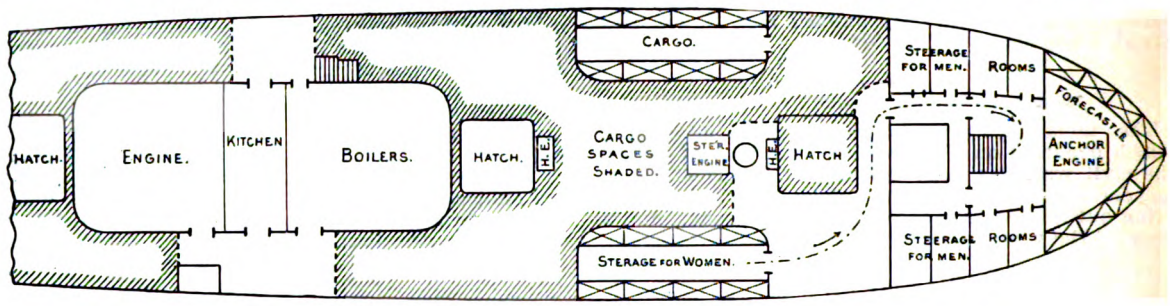
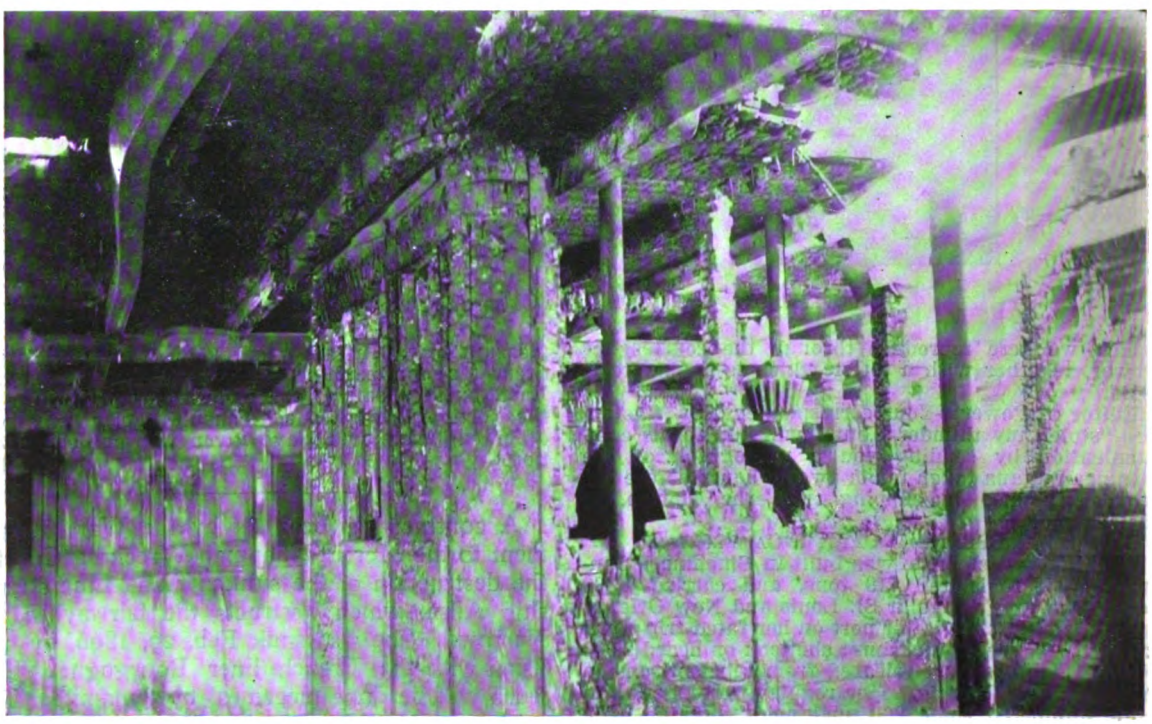
MISHAPS AT SEA.

Disastrous Fire on S.S. Leona.

A fire which caused the loss of thirteen lives and threatened the destruction of the Mallory line steamship Leona broke out early on the morning of May 9, while the vessel was on a trip from New York to Galveston. The Leona had taken on a miscellaneous cargo, and sailed from New York the previous afternoon, carrying a number of saloon and steerage passengers. Ten of the latter were burned to death, along with three of the crew. The Leona is one of the ordinary type of passenger vessels in the Southern trade. She has three decks; upper, main and lower, and it was on the main deck forward that the fire originated. A rough sketch of the deck is printed, showing the location of the various compartments, and the large quantity of freight which was carried on this deck. This freight was composed mostly of jute in bales, matches boxed up, and sewing machines in crates. When the fire was first noticed the ship's carpenter immediately notified the engineers on watch, and the fire pump, a powerful Cameron pump, was started. The vessel was steaming against the wind at the time, and the captain at once changed his course and headed north, so that the draught would not help to carry the fire aft. As there were only two lengths of hose available, the quantity of water thrown did not reach the capacity of the pumps, which were kept steadily at work for about six hours. The engineers who were not on watch came on deck and gave valuable aid in extinguishing the fire. They cut holes in the upper deck, through which streams of water were sent, and, removing the main hatch, attacked the fire in the rear, as it threatened to spread and make the engine and boiler rooms untenable. The fire soon rendered useless the steam steering gear, and the hand gear was rigged in the tiller room aft. When the fire had gone down sufficiently the loading ports in the sides opposite the main hatch were opened and much of the deck cargo thrown overboard. The fire is supposed to have started among the cargo close to the men's steerage on the port side. This speedily cut off the exit from the women's steerage on the starboard side, as the passageway between the cargo piled over the fore hatch and the forward bulkhead was less than two feet wide. While the fire was in progress the steamship City of Augusta, in response to the Leona's signals of distress, steamed close up



ROUGH SKETCH OF MAIN DECK S.S. LEONA, SHOWING SPACES FILLED WITH FREIGHT.



AFTER THE FIRE, LOOKING ACROSS MAIN DECK FROM WOMEN'S STEERAGE.

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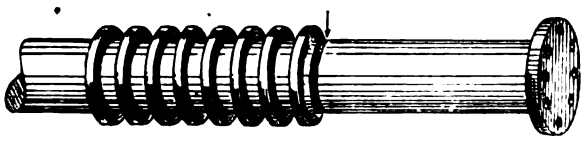
and kept alongside for several hours. About noon the fire was out and the vessels parted company, the Leona returning to New York. During the fire the engineers and firemen on watch kept steadily at work, and discipline in this department was strictly maintained.

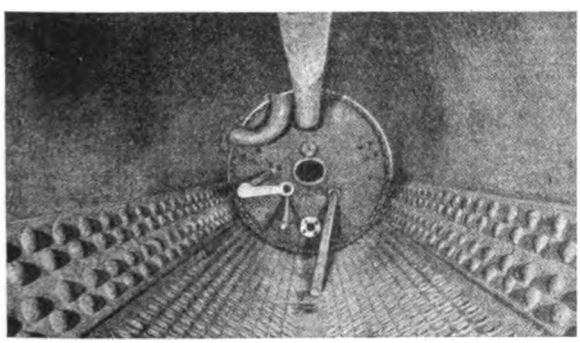
Broken Thrust Shaft Replaced at Sea.

On her last westward voyage the Anchor liner Circassia broke her thrust shaft. The engineer staff replaced it with a spare one carried, and she resumed the voyage to New York, arriving here only 60 hours



FRACTURED THRUST SHAFT S.S. CIRCASSIA.

late. The fracture occurred at the forward end of the thrust bearing, close to the first collar. The shaft was wrought iron 17 in. dia. and 27 ft. long. The break was remarkably clean, as though the shaft had been sheared asunder. Each length was left free to revolve independently, owing to the absence of ragged ends. The engineer on watch at the time of the mishap was close to the throttle valve lever when he heard a peculiar noise from the direction of the tunnel, and suspecting a break he promptly shut off steam. The engines had come to rest before the propeller end of the shafting had ceased to revolve. Chief engineer Moncur decided to go ahead with the repairs. Portion of the plating of the after bulkhead of the engine room had to be removed, as the thrust bearing was in the tunnel. The spare shaft was an easy fit, as it had been in use before, and when the voyage was resumed gave no trouble whatever. On the arrival of the vessel in port here the shaft was not taken out of the bearing, but the coupling bolts were removed and replaced with new bolts a fit thicker, the holes having been reamed out. This was simply a precautionary measure. The Circassia made the trip home in her usual time. Before



STEAM CHAMBER IN YARROW BOILER AFTER MISHAP.

she leaves port again a new Whitworth's fluid compressed steel thrust shaft will be fitted. This was the first accident of the sort which happened this fine boat, though she has been in service for a number of years.

Accident to Torpedo Destroyer.

It will be remembered that the Corrientes armored torpedo boat destroyer, built for the Argentine Government by Messrs. Yarrow & Co., lately returned to London, having been damaged in the Bay of Biscay on her way out. It was reported at the time that the vessel was strained owing to the very heavy weather she encountered, but on examination such was found not to be the case. It appears that she ran foul of some wreckage in the Bay during the storm, which damaged the bottom plating of the hull. This led to water gaining access to the forward stokehold, in addition to which water found its way down the forward funnel. The stokers report that at the time they turned back there was 3 ft. of water in the forward stokehold, which it was found impossible to clear, owing to the pumps getting choked with coal dust. There were in all six of Yarrow's patent water-tube boilers, and it appears that one of them ran altogether short of water through the pump stopping and the stokers having left the stokehold. This took place at a time when there was a fairly heavy fire, which was not extinguished until the water level had dropped to 3½ ft. below the upper tube plate, leaving all this portion of the tubes dry and subject to the action of the furnace, and no doubt some part must have been raised to a red heat. The safety valve during this time was blowing off at 200 lbs. per sq. in. It is satisfactory to know that although all the galvanizing has been burnt off the tubes, and some of them are distorted, it was found possible, without expanding the tubes, to test the boiler by hydraulic pressure to 150 lbs. On examining the steam chamber and the upper ends of the tubes, it was found that they had not in the least shifted in position. The tubes in the Yarrow boiler are bell-mouthed, and the photograph, taken immediately on the return of the boat by artificial light, represents the inside of the steam chamber. The boiler is at present being retubed, which is being carried out without removing the boiler from the boat or shifting it from its original position.—The Engineer, London.

A very complete description of Eugene Higgin's twin screw yacht Varuna, illustrated by numerous engravings, is published in the May issue of the Rudder. The dimensions are: length over all, 300 ft.; breadth, 35 ft.; depth to upper deck, 18 ft.; tonnage, Thames measurement, 1,564 tons. The hull is of mild steel, with eight transverse water-tight bulkheads. She is also fitted with a double bottom in which there is space for 66 tons of water ballast, and for 9,000 gallons of fresh water. The machinery consists of two triple expansion four cylinder engines, with cylinders 22 1-2 in., 38 in. and two 40 in. by 27 in. stroke. They are very simple in design, with open fronts, the cylinders being carried on turned steel columns on the starting side of the engines. The valve motion is the ordinary double bar Stephenson link. The condensers form part of the back framing, and the air pumps are worked off the high pressure crosshead, by the usual levers. Steam is produced in eight single ended Scotch boilers 11 ft. 9 in. by 7 ft. 6 in., each having 4 furnaces, and working at 160 pounds pressure. Forced draught on the closed stokehold plan is provided for. Electricity is used for lighting, and for driving ventilating fans in the living quarters. The refrigerating plant maintains a low temperature in the provision room, which is 14 ft. by 9 ft. On her trial trip between the Cloch and Cumbrae Lights on the Firth of Clyde, a mean speed of 16.73 knots was obtained with 3,995 indicated horse power, the engines making 158 turns. The mean load draught is 15.5 feet. The builders were A. & J. Inglis, of Glasgow.

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EDUCATIONAL.

THE INDICATOR APPLIED TO THE MARINE ENGINE.—3.

BY HENRY L. EBSEN.

To locate the different points on the indicator diagrams with any degree of accuracy, it is necessary that the gear for taking them be carefully adjusted, as large engines have a stroke anywhere between four and six feet, and any distortion of the cards would show the point of cut off to be several inches of stroke more or less from where it ought to be, in addition to giving inaccurate figures for horse power. This is a matter, surprising as it may seem, which does not receive the attention that it deserves, and it is a fact that the gears on most engines give diagrams which are more or less distorted. The reason of this is not so much an oversight, but lies in the fact that space in a ship's engine room cannot easily be spared. Owing to the length of stroke and high piston speed in modern engines, it is impossible, without endangering life and limb, to use any reducing gear secured directly to the crosshead, to be attached or detached at pleasure when the engine is running. Stopping for this purpose is out of the question. The indicator gear must be attached permanently. In ocean steamers, if it is considered that it takes between 800,000 and 1,500,000 revolutions to cross the Atlantic, it is evident that the gear must be substantially built, and be a part of the engine itself. If not, it is sure to get slack in the bearing and probably cause damage to neighboring parts. Most of the gears used are of the usual lever type, swinging from a stud on the column, and driven from the crosshead by a connecting link, the lever being set perpendicular to the guide faces when the piston is at half stroke. According to the general rule a lever ought never be shorter than one and one-half times the stroke, in order that the diagrams shall not be distorted. This rule is almost always violated, the levers usually being about as long as the stroke and in some cases even shorter. The cause of this is simply that there is no place to attach the lever if it were made the proper length, as it would project outside, beyond the columns. Even if provision could be made to swing it from some support, it would interfere with the passageway along the middle platform at each cylinder, or come in conflict with the weigh shaft, and from a practical standpoint be generally undesirable. In some cases the connecting link is attached to the furthest guide shoe to get a longer lever, but this is rarely practicable, as most of the connecting rods have fork ends at the crosshead, and the levers must have quite an offset to clear the brasses. For these reasons short levers are used so frequently, and if the positions of such a lever be plotted down, Fig. 7, for certain equal divisions of piston stroke AB, BC, CD, and DE, it can be plainly seen that these divisions as transmitted to the diagram ab, bc, cd, and de will not be proportionately equal, but vary in size. If the lever is not set perpendicular to the guides when the piston is in the middle of the stroke, or the indicator string is not perpendicular to the lever under these conditions, the diagram will be still further distorted. Fig. 8 is a diagram taken from a cylinder with a short lever and faulty setting of the same, and Fig. 9 is a diagram taken from the same cylinder after a correct gear was fitted.

Of the different gears designed to give accurate results, one may be mentioned here, Fig. 10. It is a telescopic gear, consisting of a steel tube sliding inside a brass tube, the former attached to the column and the latter to the crosshead. As the crosshead moves up and down the tubes draw in and out similarly to the sections of a telescope. The part of the tube at the column is slotted and fitted with a saddle block which drives a vertical bar between guides, in the same manner as a valve stem is driven. The bar

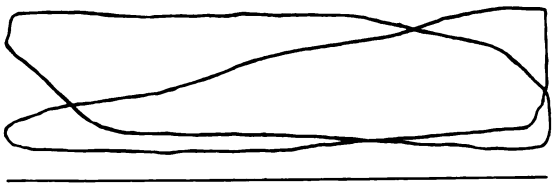

FIG. 8.

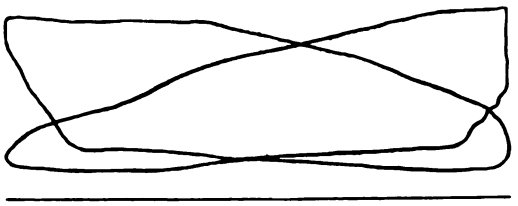

FIG. 9.

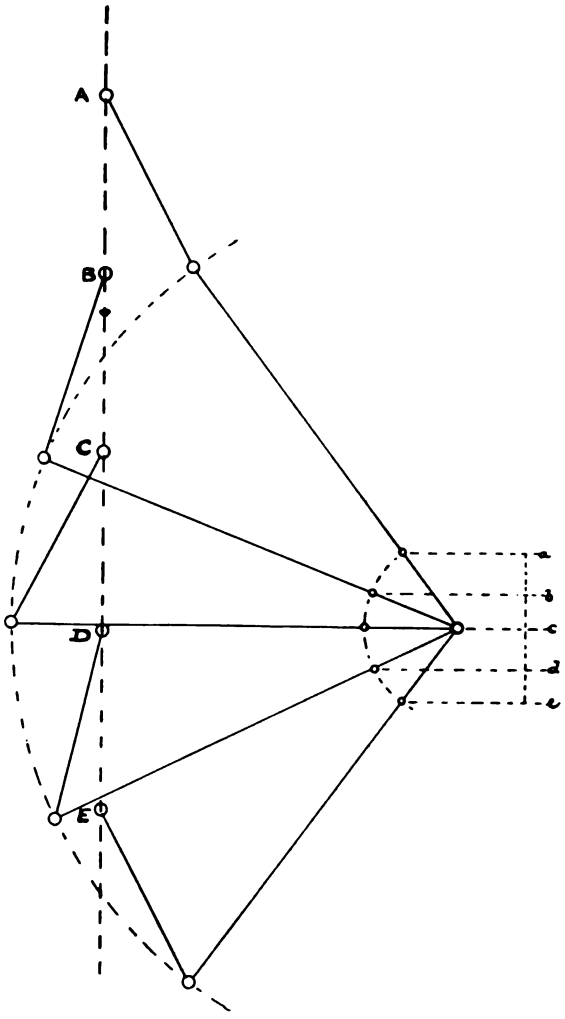

FIG. 7.

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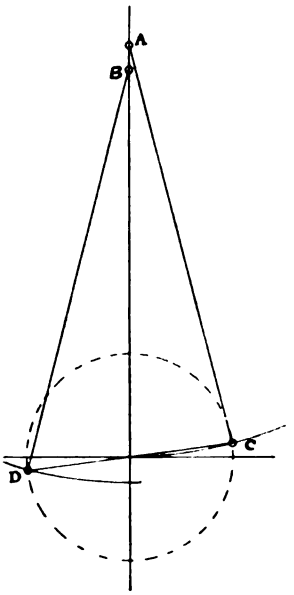

FIG. 12.

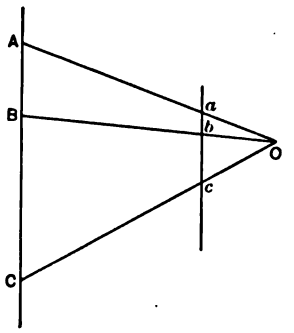

FIG. 11.

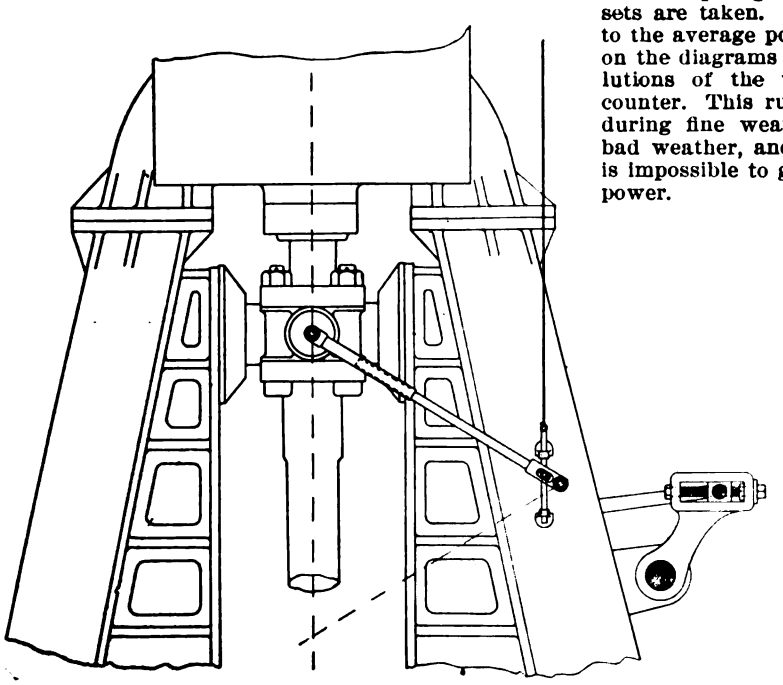

FIG. 10.

connects to the indicator string. This gear wears well, takes up little room, and the action of it is mathematically accurate. In Fig. 11, AC is the path of the crosshead, ac is that of the bar and parallel to each other, and the distances ab and bc which the bar travels will be in proportion to the distances AB and BC of the travel of the crosshead and piston.

Some faulty designs of gears and the arrangements of the same are sometimes ludicrous. For instance: in a certain quadruple expansion engine the cranks of alternate cylinders were placed at 180 deg., or opposite each other. The usual lever gear connected to one crosshead was made to serve its own cylinder and the one in which the crank stood opposite. In Fig. 12, let AC be the connecting rod of the first cylinder, when the piston is in the middle of the stroke. The crank of the other cylinder will be opposite at D and BD would be the position of its connecting rod, showing that its piston was a distance AB below the center of the stroke. As connecting rods of marine engines are very short, from two to two and one-quarter times the length of the stroke, the distance AB becomes quite a percentage of the stroke; in this particular case it amounted to seven inches. So if the gear attached to the first cylinder gave correct diagrams for its own cylinders, it would distort the diagram of the other cylinder, showing the points of cut off in the latter seven inches of piston stroke away from where they ought to be.

On account of the size and length of the cylinders of marine engines, the indicator string is usually quite long, especially when there is not a straight lead from the gear and it has to pass over a pulley. In such cases precautions must be taken against stretching. A good kind of string to use in such cases is one that contains a core of fine brass wire.

In noting the revolutions at the time of taking diagrams on engines of high power, making from 75 to 100 revolutions per minute, one-quarter of a revolution more or less represents considerable power. As a tachometer is unhandy, it is customary to take the average revolutions on the counter for five minutes or thereabouts during the time the diagrams are taken. As it would be impossible without extra help to take diagrams at short intervals during the whole trip to get the average power, usually, several sets are taken. The power on these is proportional to the average power, as the cubes of the revolutions on the diagrams are to the cube of the average revolutions of the voyage taken from the revolution counter. This rule is sufficiently accurate on a trip during fine weather. If there are several days of bad weather, and the engines race to any extent, it is impossible to get reliable figures for average horse power.

New Liner Launched.

The new twin-screw liner "Kaiser Wilhelm der Grosse," for the North-German Lloyd, was launched from the builder's yard in Stettin last month. When completed, she will probably make new records in transatlantic passages. The new vessel is 649 feet long and will displace about 20,000 tons when ready for sea. A sister-vessel, the "Kaiser Friedrich," is well advanced toward completion. These will be the largest vessels ever built in Germany.

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HOME AND FOREIGN EXCHANGES.

Marine Engineering Fifty Years Ago.

In the year 1842, that is to say, fifty-five years ago, a sharp discussion took place between Mr. William Pole and a gentleman who wrote over the name "Vulcan," in the pages of the Civil Engineer and Architects' Journal, concerning the merits and demerits of certain types of marine engine, says the Engineer, London, editorially. Who "Vulcan" was we are quite unable to say. He appears to have understood his subject fairly well, and made a good fight, although even in those days Mr. Pole was no insignificant adversary. The controversy no longer possesses any practical interest. It turned on the comparative merits of the direct-acting and the side lever paddle engine, Mr. Pole standing up for the former and "Vulcan" for the latter. We quote the discussion now for the sake of the curious light it throws on the position of marine engineering at or about the middle of the present century.

We find, for instance, that Messrs. Seaward had issued a pamphlet in which they claimed for their new type of direct-acting engines a remarkable economy. The firm guaranteed a maximum consumption of 6.5 lb. of good coal per horse-power per hour. "Vulcan" seems to have doubted that this was feasible, at all events with direct-acting engines. If this was considered a performance of which to be proud, what must have been the consumption with inferior machinery? We have no reason to think that Messrs. Seaward over or under-stated the facts. A consumption of 6½ lbs. of coal per horse power per hour was a very good performance for a marine engine in those days, judging by contemporary records. It is worth while to endeavor to discover the causes which brought about so enormous an expenditure of fuel.

At the outset we are met by the difficulty that the words "horse power" seem to have been used in a very vague way. We are not quite sure, therefore, to what Messrs. Seaward's statement refers. Marine engines in 1842, and for many years subsequently, were rated at their nominal power. We have found it next to impossible to find out what relation the nominal bore to the real or indicated horse power in a general way. We believe we shall not be far from the truth if we say that the indicated power in those days seldom, if ever, exceeded the nominal power by two to one. Indeed, so long as the pressures were kept down to 5 lbs. or so, the nominal and the real powers must have been nearly the same, save in special cases. We find H. M. S. Amphion, with engines of 300 horse power nominal, indicating on her trial trip 592 horse power; but the safety valve load was 10 lbs. Probably if we say that the indicated was twice the nominal we shall concede all that can be demanded for the engines of that day. It seems tolerably clear, therefore, that Messrs. Seaward, when writing about the consumption of coal by their machinery, were referring to the indicated horse power, and on that basis we must deal with the question. It is by no means as easy at it seems to be at first sight to give the true reasons for this enormous consumption. Indeed, the more fully we investigate the subject the greater does the difficulty apparently become. In the first place there is no doubt that many land engines were doing better than much larger marine engines. Several years ago we ourselves indicated an old Boulton and Watt beam engine in a spinning mill. The engine indicated only 47 horse power; worked at a pressure of 10 lbs.; had the old, long D, hemp-packed slide valves, and a Cornish boiler. According to the coal bills submitted for our inspection, the engine was giving an indicated horse power for a little over 4 lbs. of good slack per hour. This is probably one-half the consumption of the average marine engine of fifty or sixty years ago. Nor does this extravagance in the use of fuel by the marine engine appear to have passed unnoticed. Various reasons have, indeed, been adduced to account for it. One is that the firemen were grossly incompetent; another that the brineing of the boilers wasted a tremendous quantity of fuel. None of these is, we think, an adequate explanation. It is true that machine tools were not half a century ago what they are now. But, on the other hand, there were available some of the best workmen the world has ever seen. Indeed, no one who has had the opportunity of examining old marine engines by such men as the Maudslays or Penns can have any doubt on this subject. Although built at a period ten years later than that of which we write, the paddle engines of the Great Eastern, with four oscillating cylinders 74 in. dia. and 14 ft. stroke, were magnificent examples of mechanical engineering of the finest possible finish. Metallic pistons were in use, and there is no reason to think that there was any appreciable leakage. As for the art and mystery of firing, that seems to have been as well understood in those days as now. It is easy to show that, although brineing caused a loss, it was not very serious. As a rule the water was not allowed to rise in density much above 3-32. This meant that about one-third of all of the feed water pumped into the boiler cold had to be blown out hot. A very simple calculation will show that this did not represent at the worst a loss of more than 6 or 8 per cent, and that was reduced in many vessels by making the outgoing hot water raise the temperature of the incoming feed.

No doubt many of our readers will say that the true origin of the waste of fuel is to be sought in the low pressure and lack of expansive working. Yet it is not only possible to push this argument too far, but it seems to be invariably so pushed. The work which a pound of steam is capable of doing without expansion is not far from being the same for all pressures. We shall not be much wrong if we say that it is equivalent to about 60,000 foot-pounds. If then, we have a boiler pressure of 15 lbs. above the atmosphere, and allow for clearance, we shall need about 33 lbs. of steam per horse power per hour. But the engine cannot work on a perfect vacuum, consequently an allowance has to be made, but after this has been done we still find that about 37 lbs. of steam should suffice to give an indicated horse power per hour. A tremendous consumption, it is true, but not sufficient to account for 6.5 lbs. of coal per horse power per hour. If the steam was cut off at three-quarter stroke its efficiency would be augmented in the ratio of 1.3 to 1, and the consumption of steam would drop to about 28.5 lbs. If the cut-off took place at half stroke the efficiency would be augmented in the ratio of 1.88 to 1, and the quantity of steam needed would fall to about 20 lbs. per horse per hour. At the latter rate, if a pound of coal produced 10 lbs. of steam, we should have a horse power for two pounds of coal, or about one-third of the actual consumption.

Obviously just here we come in contact with the question of cylinder condensation. We know that because of initial condensation there must be more steam used than would be needed if we worked with a non-condensible fluid, or employed an absolutely non-conducting cylinder and piston. But the initial condensation ought, according to all received argument, to be small. The temperature of steam with a total pressure of 30 lbs. on the square inch is 250° F.; that of the condenser would be about 140° F. The temperature range would therefore only be about 110° F., which is very moderate. It will be admitted, we think, that up to the present the true cause of the extravagnt consumption of fuel has not been stated. We believe that it is in the boiler we must seek for the reason. Theoretically, there is nothing about the engine to explain the enormous waste of coal. The land engine did not need it, and

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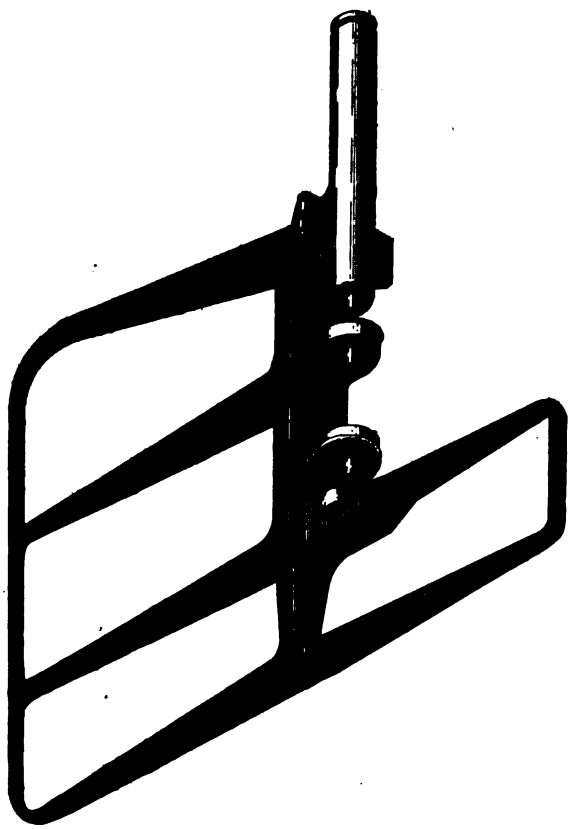
the land engine was not superior to the marine engine. There were, however, two prominent defects in the old type of marine boiler. One was that in a very short time, no matter how carefully brineing was conducted, the heating surfaces became incrusted to an extent of which the modern seagoing engineer has no conception. There can be little doubt that whole voyages have been made with the furnace crowns nearly if not quite red hot. They did not come down because the pressure was so small. But the flues were in even worse condition than the furnaces. These last were scaled as often as possible; but the flues presented plenty of inaccessible places. Even if the surfaces had been kept in first rate order, the flue boiler must have been wanting in economy. Salted up as it was most of its time, we shall overrate its performance if we say that it gave six pounds of steam for every pound of coal burned on its grate. But this is not all. No particular care was taken to keep the water clean. There is excellent reason to believe that the old box boiler never supplied dry steam. The furnaces were crowded in, and little or no consideration was shown for circulation. It is not, we think, necessary in the present day to stop here to explain how fatal to economy is water in steam. That the old type of marine boiler did not supply dry steam is to a large extent—though perhaps indirectly—proved by the great benefit derived from fitting superheaters. If we suppose that the steam was dry when it entered the superheater, the reduction in the consumption of fuel brought about by the apparatus would be inexplicable on theoretical grounds. Thus, for example, the P. and O. steamer Colombo had her consumption cut down from 52 tons per day to 43 tons by the use of a superheater. In the case of the Norman, a Union steamship, the superheater saved 23.5 per cent. In the P. and O. ship Ceylon the saving of coal was 32 per cent. Such economies are only to be explained on the theory that the boilers supplied wet steam before the superheaters were fitted, and that they wasted a great deal of heat up the chimney. It is worthy of note in this connection that the advent of the surface condenser involved a great reduction in the consumption of coal, while pressures were still low, the engines not compounded, and the ratio of expansion seldom reaching two to one. No doubt the saving was due to augmented boiler efficiency.



FINISHED RUDDER-FRAME FORGING FOR BATTLESHIP.

In the light of existing knowledge it seems strange that marine engineers of the highest reputation should have boasted of a consumption of fuel so enormous as 6 lbs. per horse power per hour. But marine propulsion was a plant of slow growth, and the difficulties which lay in the way of its development were very serious. The marine engineer had to think of a hundred things at once, and to provide for contingencies undreamed of. It was of infinitely more importance that his engines and boilers should not break down than it was that they should be economical in fuel. Experience had to be acquired. Experiments involved not only a large outlay but serious risk, and the present position of marine engineering is due to the caution with which every step in advance has been made sure, and carefully consolidated before another was taken. Marine engineering is of slow growth, but so is the oak, for centuries the emblem of Britain's naval supremacy.

Rudder Frames for U. S. Battleships.

The Cleveland City Forge & Iron Co., Cleveland, is now at work on four rudder frames for the battleships Kearsarge, Kentucky, Illinois and Alabama the first three of which are now under construction by the Newport News Ship & Engine Building Co., Newport News, Va., while the fourth is being built by the Cramp Ship & Engine Building Co., Philadelphia. All four rudder frames are substantially like the one shown in our illustration. They are made from double refined wrought iron and have an extreme height of 20 ft. 9⅛ in., with an extreme width of 19 ft. 3 in. The rudder stocks are 18 in. finished dia., and each has a 5-in. hole bored axially through it. Owing to its intricate shape the rudder stock portion of the frame had to be forged solid throughout and machined out afterward. The stock forging weighed about 25 tons in the rough, exclusive of the bows, counterbalance and braces. The weight of the finished frames will be somewhat less than this, but the exact weight cannot be given until the completion of the work.

These rudder frames are the heaviest and most intricate ever attempted in this country, says the Iron Trade Review, and so far as our information extends none like them have been made abroad in iron. Owing to their unwieldly size they cannot be transported by rail, the tunnels and bridges making this impossible. Moreover, the ordinary canal boat, with its narrow hatches, would not accommodate them. The company has therefore chartered one of the Cleveland Steel Canalboat Company's boats to take the rudders to New York, though it is not entirely certain that all can be so disposed that the four can be taken in one boat. From New York they will be sent to the two shipyards by steamer.

Power Estimates on Ocean Voyages.

Mr. Nisbet Sinclair, in a paper read before the Institution of Engineers and Shipbuilders of Scotland, has been attacking the rather difficult problem of arriving at fairly definite figures in regard to the mean power required to drive any given ship on ocean voyages, says Engineering, London. The experiments were undertaken in order to test the efficiency of certain propellers, but their chief value lies outside their

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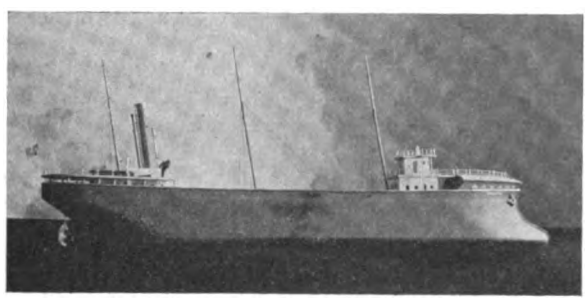
ostensible object. There were several sister ships engaged on the same route. Each voyage was continuous, and the time on the voyage, the distance run, total revolutions, and draught of water at the end of the voyage were carefully noted. Indicator diagrams were also taken. These observations were continued for about a year. The data were not sufficient to determine the average power on any one voyage, but the long series of records enabled the general character of the ship's behavior to be closely estimated, and what the power and revolutions would be under average conditions. Accordingly the card powers were reduced to a common displacement on the assumption that the indicated horse-power varied as the two-thirds power of the displacement. The corrected powers were plotted on ordinates of card revolutions, the fair lines through the spots being held to represent the average power for any number of revolutions within the range of the curve. The average revolutions during each voyage were then plotted on ordinates of average speed in knots for the voyage, the fair line being taken to show the average revolutions for any speed in the range of the curve. From these two curves a speed and power curve was constructed, representing the average behavior of the ship, or, as Mr. Sinclair put it, the "normal locomotive value."

Vessel for Winter Lake Service.

Writing from West Superior, Wisconsin, a correspondent of the Chicago Record says: A gigantic scheme is now under way which has the ultimate end in view of navigation on the great lakes through



MODEL OF PROPOSED WINTER LAKE STEAMER.

the entire winter. Should the plans as at present outlined work out satisfactorily they will necessitate the building of a new and novel fleet of winter lake boats and tugs at a cost of $1,500,000.

Commodore B. B. Inman, of Duluth, a gentleman of a business turn of mind, who has followed the lakes for a number of years as a vessel and tug operator, has invented and proposes to build a new type of steel vessel, which, with the aid of powerful tugs stationed at the obdurate points along the great lakes, will run between the upper and lower lake ports through the coldest of northern winters. At first thought such an undertaking would seem visionary and impractical, though there are persons of experience who assert that with the right kind of vessels such an undertaking would not be impossible.

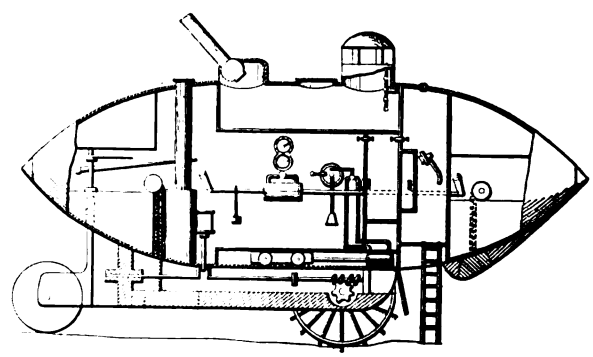
Mr. Inman has given the subject thought for a number of years and is convinced that winter navigation of the lakes will ultimately come. He has invented and with the aid of eastern capital proposes to build a fleet of six steel vessels for this service. The boats are designed to be modern in every way. The changes in the hull, as compared with the modern summer boats, will be in the bow, which will run under the ice and lift it up. The bow will also be wider than is the stern of the ice breakers, so that after the channel is broken by the bow of the boat the remaining portion may pass without injury or friction. These vessels are designed to be of the very largest size, carrying from 4,000 to 6,000 tons of freight, about 530 ft. in length, 48 ft. beam forward and narrowing to 45 ft. aft. They will carry about 30 per cent additional power, possess steel wheels, and will be built throughout for ice breaking.

Commodore Inman has aproached the head-of-the-lakes flour millers on the subject and learned that if winter nevigation can be made practicable they will gladly enter into a contract for their entire winter product, which at present goes by rail to eastern and foreign markets during the winter. Naturally freight rates in the winter, with such vessels, would be higher than in the summer, when the lakes are free from ice, but Mr. Inman thinks that the rail rate could be reduced by the use of his vessels.

SELECTED PATENTS.

581,213—SUBMARINE VESSEL. *Simon Lake, Baltimore, Md. Filed Apr. 5, 1893.*

In a submarine vessel provided with means for propelling the same, the combination of oscillatory vanes arranged upon both sides of the vessel, a pressure-gauge communicating with the exterior of the vessel and provided with an index-hand actuated by the pressure of the surrounding water, a motor for oscillating the vanes and an electrical controlling device thrown into and out of operation by the index-hand for starting, stopping, and reversing the motor. A cylinder provided with a piston, piston-rods connected to cranks carried by the vanes, a compressed air reservoir, means controlled by a valve for admitting compressed air to the opposite ends of the cylinder, a pressure-gauge actuated by the pressure of the surrounding water, an armature carried by the stem of the air-valve, two series of electromagnets adapted to be connected with an electrical generator by independent conductors and operating to move the armature in opposite directions, two series of contacts adjustably arranged in the path of the index-hand of the pressure-gauge, and conductors connecting the contacts and electromagnets. The combination with a shifting weight adapted to move in fore-and-aft ways, of a motor for shifting the weight in opposite directions, and means controlled by the movements of the vessel for automatically starting, stopping and reversing the motor to keep the vessel on a level keel. A cylinder and piston for shifting the weight in opposite directions, a compressed-air reservoir communicating with the opposite ends of the cylinder, a valve for controlling the admission of compressed air to the cylinder, and a pendulum for operating the valve when the vessel sinks by the bow or stern. Lazy-tongs connecting the piston and weight, a com-



pressed-air reservoir communicating with the opposite ends of the cylinder. The combination with an air-tight diver's chamber provided at its bottom with a trap, an auxiliary chamber communicating there-

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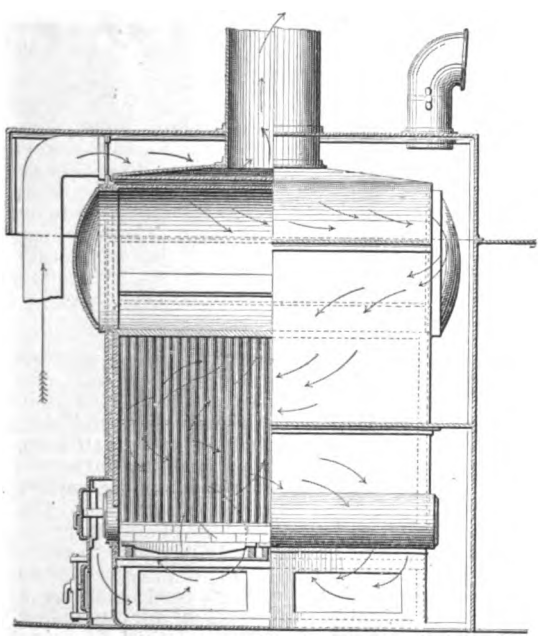
with by a door, a door affording communication between this auxiliary chamber and the interior of the vessel, a compressed-air reservoir, valved pipes connecting the chambers with the air-reservoir, pressure gauges for indicating the pressure of the air in the chambers, and a pressure-gauge for indicating the pressure of the water surrounding the vessel. The combination with a submarine vessel of wheels projecting below the bottom of the vessel and adapted to rest upon the water-bed, means for holding the vessel in contact with the water-bed, means for propelling the vessel over the water-bed upon the wheels when submerged, and means for guiding the vessel over the water-bed, by a steering-wheel. A steering-wheel journaled in the rudder of the vessel and projecting below the bottom to engage the water-bed, this wheel serving to guide the vessel over and help support it upon the water-bed, and means for operating the steering-wheel from the interior of the vessel when the latter is submerged.

580,060—STEAM-BOILER. *Horace See, New York, N. Y. Filed Sept. 12, 1896.*

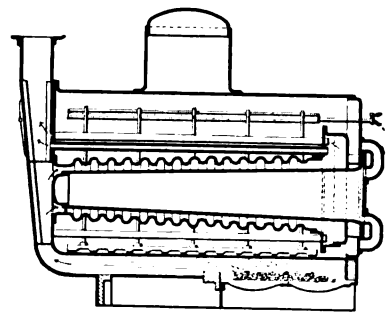
A steam-boiler having a fuel-supply opening in its front wall and above its grate, draft-openings in both front and side walls and below the grate, a source of air-supply and an air-casing; the air-casing inclosing all of the openings and conducting the air-supply directly thereto. The air-casing extending around the sides and rear of the boiler. A steam-boiler, having a fuel-supply opening, provided with a hinged door, a draft opening below its grate, an air-casing, having an opening provided with a hinged door in front of the fuel-opening, a source of air-supply communicating with the casing, and a mechanical connection between the hinged doors, whereby the opening and shutting of the outer door causes the simultaneous opening and shutting of the inner door. A bulkhead or partition in front of the fuel-supply and ash-pit openings in the boiler, an air-blower communicating with the space between bulkhead and boiler, a hinged door closing the fuel-supply opening and a hinged door corresponding to it in the bulkhead. A steam-boiler, having water-chambers on each side of its grate, a steam-drum above the grate, in-



clined tubes connecting the drum and chambers, a casing surrounding these parts and communicating with the uptake, openings in the casing above and below the grate, an external casing surrounding the inner casing, and provided with a door for access to the fuel-supply opening, and an air-blower communicating with the upper part of the external casing. Openings in the front and sides of the ash-pit, whereby the blast from the blower is caused to descend between the casings to the ash-pit openings, thus becoming heated by contact with the inner casing, and to rise through the grate and fire-space to the uptake.

582,416—STEAM-BOILER. *John E. Friend, Wellington, New Zealand, assignor to the Friend's Steam Generator and Imporous Butter Box Company, Ltd., same place. Filed Jan. 22, 1897.*

In a boiler, a conical flue extending through the same, a conical water-tube within the flue, the smoke-box at the large end of the flue, the fire-tubes extending from the smoke-box through the upper part of the boiler to the chimney and the connections between the conical water-tube and the upper and lower water-spaces of the boiler. 2. The flue extending through the boiler, the smoke box within the boiler at one end of the flue, the water-tube let in through the wall of the boiler and through the smoke-box, and the ring about the water-tube and between the smoke-box and



the boiler shell. 3. In combination with the boiler having the flue extending through it with the smoke-box at one end of the flue within the boiler, the water-tube extending through the flue and having its flanged end fitting against the boiler-shell, the ring about the tube and between the boiler-shell and the smoke-box and the tubes connecting the water-tube with the upper and lower water-spaces of the boiler. 4. The pipe extending from the lower to the upper part of the boiler to convey the sediment and the upper pocket or receiver into which this pipe discharges with means for blowing the same out. 5. The perforated troughs laid along the bottom of the boiler, the pipes extending upwardly therefrom, the receiving-pocket at the upper ends of the pipes and the means for blowing out the pocket.

A yachting and fishery exhibition is now in progress at the Imperial Institute in London.

Including battleships, gunboats, torpedo boats, and minor vessels, there are now 29 ships building for the United States Navy.

An order for an additional ferryboat for the new Twenty-third street line on the North River, New York, has been placed by the Pennsylvania Co. with Cramp & Sons, of Philadelphia.

The United States cruiser Detroit returned to this port on May 17, after an absence of more than two years on the Asiatic station. The longest runs on her trip were from Columbo to Aden, a distance of 2,100 miles, and from Bermuda to this port, a distance of 2,445 miles. The distance covered on her homeward voyage was 15,324 miles in all.

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NEW PUBLICATIONS.

BEESON'S MARINE DIRECTORY. By Harvey C. Beeson, proprietor and publisher, Chicago, Ill. Tenth annual edition, pp. 426. With illustrations. Price $5.00.

This standard book has just been issued with revisions to date. The list of American steam vessels on the lakes, with which classification the subject-matter of the book opens, occupies 43 pages. In this space the vessels are arranged alphabetically with note of their dimensions, class, date and place of build, and ownership. This is followed by bulk figures of vessels enrolled at the various custom houses on the great lakes, the table showing a total, among others, of 1,796 steam vessels. Of this total Buffalo heads the list in point of numbers, having 257 to her credit, and Dunkirk, N. Y., is the least, with two only. The list of sailing vessels is included in the space of 20 pages. A new feature of the work is a record of the engines and boilers of lake vessels. According to the publisher, it gives facts and figures about the machinery of one-third of the steam tonnage on the lakes. Besides these principal divisions of the book, there are data concerning largest cargoes carried, vessels whose names have been changed, weather bureau, federal courts, etc. There are also several newsy articles on matters of special interest to lake navigators, and besides many good process engravings are distributed throughout the work, so that in the make-up the usual dry-as-dust appearance of such publications is avoided. The book shows evidences of careful work, and its accuracy is attested by ten years of successful publication.

CATALOGUES.

A very neat little photograph of a compound engine is being distributed by The Fore River Engine Company, Weymouth, Mass. Everybody applying will receive one all mounted, ready to stick up.

A fully illustrated catalogue with dark green and gold cover has been issued by The Snow Steam Pump Works, Buffalo, N. Y. All sizes and kinds of pumps are illustrated and described, several being especially adapted to marine uses. It is an unusually handsome catalogue, comprising 112 pages.

At the beginning of the year the Knowlton Packing & Supply Co., 19 Pearl street, Boston, distributed 10,000 copies of a pocket calendar for 1897. The edition was exhausted, and we have just received a copy of the second edition of a thousand or more, which is ready for distribution either from the Boston office or from the New York office, 54 John street.

Every engineer should send to the Wheeler Condenser & Engineering Co., 122 Liberty street, New York, for its latest catalogue regarding the Wheeler improved surface condenser. This is a catalogue of 30 pages, handsomely illustrated and well printed, illustrating and describing fully the various types of condensers and other marine specialties manufactured by this company.

A very neat folder has been issued by Henry R. Worthington, New York, giving a partial list of foreign naval vessels which are equipped throughout with Worthington pumps. The list includes about 60 vessels in the English navy, 10 in the Russian, 12 in the German, 6 in the Austrian, and one or more in the Danish, Brazilian, Spanish, Portuguese, Chilian, Argentine and Japanese navies.

A pamphlet of "Testimony in the Case of Economy Drilling Compound vs. Oil, et al." is being sent out to engineers, both marine and stationary, by the White & Bagley Co., Worcester, Mass. It comprises about 50 pages of reproductions of letters received from prominent manufacturers and steam vessel owners, speaking in high terms of the value of this company's lubricating compound.

Every engineer who is interested in the subject of packing should send for a copy of the new catalogue just issue by A. W. Chesterton & Co., 49 India street, Boston, Mass. It is an exceedingly interesting catalogue and is very fully illustrated with pictures of the many kinds of packing manufactured by this company. It is not an ordinary job of printing, but good lithographic effect, and the catalogue contains much information which all engineers should wish to know.

A catalogue has been issued by the Mossberg & Granville Manufacturing Co., Providence, R. I., fully illustrating and describing the Mossberg roller bearing, advertised and described elsewhere in these pages, although the catalogue shows it as adapted to many other uses besides thrust bearings. Many records of tests of the bearing are given, and other detail, so that any one interested in the subject can find all the information necessary regarding this bearing.

The Hub ball and roller bearings manufactured by the Ball Bearing Company, Watson street, Boston, Mass., are well illustrated and described in their catalogue, just issued. There are places in which ball bearings are, perhaps, more advantageous than roller bearings, and this catalogue aims to explain why these conditions exist. The subject of reducing friction is one in which every engineer is deeply interested, and he will find much in this catalogue to interest him.

"Perfection in Anchors" is the title of a catalogue just received from the Baldt Anchor Company, Chester, Pa. The special features of this anchor are fully illustrated and described within these pages and will interest every man who has any use for an anchor. The special advantages of this anchor are fully described, together with tests that it has withstood and tables of anchors required for vessels of various kinds. Several testimonials are also published from well-known marine people.

A supplementary catalogue has just been issued by Murray & Tregurtha, South Boston, Mass., illustrating and describing their new gasoline engine. Several illustrations are given showing that this engine is of a type quite different from ordinary launch engines, and other pictures illustrate launches recently constructed by this company. The catalogue also contains a number of testimonials. This catalogue is supplementary to a larger one describing and fully illustrating the steam engines, launches, and water tube boilers built for this company.

A very attractive catalogue has reached us from The Marine Iron Works, Clybourn and Southport avenues, Chicago. The special work of this company is the building of high grade marine machinery and complete steam craft of medium and small sizes. Everything offered for sale is its own manufacture, and numerous illustrations show in detail the various types of boats, engines, etc., manufactured. The boats include almost everything from small motor launches to stern paddle-wheel pleasure yachts, ferryboats, fireboats, etc. The catalogue is an excellent specimen of press work and contains a great deal of valuable information for intending purchasers of boats. It has an especially interesting series of pictures illustrating the various types and sizes of steam engines manufactured. Copies of the catalogue can be had upon application and by mentioning Marine Engineering.

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